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10. and 11. (being both in one Plate) bet. 186 and 187.		

Jan. 11. 1725-26.

I Have read this Book, and
think it will be very use-
ful to Beginners.

J. T. Defaguliers,
L. L. D. F. R. S.

A N
INTRODUCTION
T O
*Geography, Astronomy,
and Dialling.*

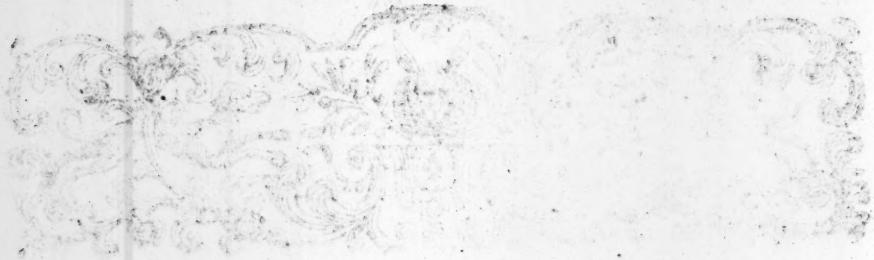
Containing the most
Useful ELEMENTS
Of the said
SCIENCES,

Adapted to the
Meanest CAPACITY,
BY THE
DESCRIPTION and USES
OF THE
Terrestrial and Celestial Globes.
WITH AN
Introduction to *Chronology,*

By GEORGE GORDON.

L O N D O N :

Printed and sold by J. SENEX, at the *Globe* against
St. *Dunstan's* Church, *Fleet-street*; G. STRA-
HAN, at the *Royal Exchange*; W. and J.
INNYS, in St. *Paul's* Church-yard; J. OS-
BORN and T. LONGMAN, in *Pater-noster-*
Row; C. KING, in *Westminster-hall*; and by
the A U T H O R. MDCCXXVI.





To the Right HONOURABLE

Sir Robert Walpole,

Knight of the most ANCIENT
and HONOURABLE ORDER
of the *BATH*, Chancellor
of the Exchequer, and First
Comissioner of the Treasury.

SIR,



T is a great Happiness
when Persons of your
exalted Station and
Merit are pleased to
be PATRONS and
ENCOURAGERS of useful and
solid

The DEDICATION.

solid Learning ; and therefore since you have been so good as to countenance my Endeavours, I have taken the Liberty to inscribe the following Sheets to your Great Name, hoping that the Dignity of the Subject will procure a Pardon for my Presumption.

ASTRONOMY and CHRONOLOGY having been esteemed (in all Ages) as Sciences the most worthy to be cultivated, not only for the Beauty of Speculation, but for their Usefulness to Mankind, to contemplate the Glory of God, which the Heavens declare ; to examine his Handy-work in the Firmament, by the Help of those Instruments,

The DEDICATION.

ments, which bring them near to our Sight, and enlarge our View ; and to consider his Wisdom, by comparing together the Magnitudes, Distances, Courses and Causes of the Motion of the Celestial Bodies, have been from time to time the Employment of some of the best and greatest Men, who have generally made use of the Knowledge gained by this Science, to settle CHRONOLOGY, without which, the History of Nations and ancient Records of greatest Empires would become almost useless; and since Kings and Princes have been CHRONOLOGERS, I hope a good States-man will not disdain those Sciences as a Diversion, which he might be inclined to make his

[b]

Study,

The DEDICATION.

Study, if his Love for his Country, did not induce him to prefer the Service of the Publick to the highest Gratification of himself.

Here, according to the Custom of Dedications, I should draw the Picture of my PATRON, and though the utmost of my Skill would be unequal to the Task; yet the many excellent Qualities that offer themselves to view, would furnish my unskilful Hand with Materials sufficient to give a grateful Idea to all my Readers, but to him, whose Character I should draw. A PATRIOT, who has been so habituated to worship God and defend

The DEDICATION.

defend Religion, to pursue the Interest of his King and Country, and to do generous and charitable Acts, that he practices Virtue, without perceiving the Splendor it reflects on him, and would be offended at those that should offer to hold up a Glass, for him to behold his own Lustre.

All that I shall say therefore, is, that I think my self bound to wish, that you may long continue to shine with the same apparent, as well as inherent, Lustre ; and at last, when you leave this transitory World, you may die full of Satisfaction as to your Life past, and finally assured,

[b 2] that

The DEDICATION.

that you shall be rewarded, and
eternally blessed in a better.

I am,

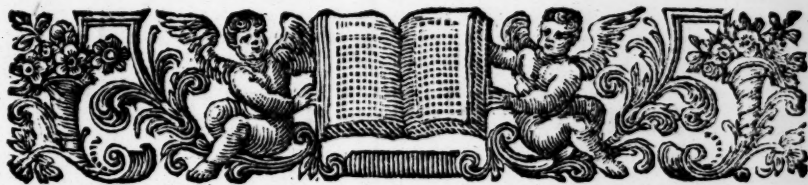
Great Sir,

Your most humble and

most devoted Servant,

GEORGE GORDON.

THE



T H E
P R E F A C E.



THE following Sheets were drawn up and put into this Method for the Use of some young Persons of Distinction, for whose tender Years, Systems of *Geography* and of the *Celestial Physicks*, would have been too hard a Study: And the Benefit which they reap'd by those Instructions, encourag'd me to publish them for the Use of Beginners. The Subject being the Principles of GEOGRAPHY and ASTRONOMY; I presume, needs no Commendation:

ii The PREFACE.

dation: Because the greatest and most eminent Persons in all Ages have made it their highest Concern to understand them.

And that the Principles of both might be the more easily represented to our Views, the Ancients have recommended (and the Moderns come into) the Use of the GLOBES; of whose Excellency all I shall say is, that they exceed all other Instruments, as they represent the Heavens and the Earth in their proper and genuine Figures, and therefore ought to be the first Study a Learner should undertake; for without a competent Knowledge of them, he will not be able to understand any Author that treats of GEOGRAPHY, ASTRONOMY, NAVIGATION, or DIALLING, &c. Therefore, my Design in this TREATISE was to make the Use
of

The P R E F A C E. iii

of them plain and easie to the meanest Capacities.

To the Principles of G E O G R A P H Y and A S T R O N O M Y, I have added a C O M P E N D I U M of C H R O N O L O G Y, the Usefulness of which I cannot better recommend than in the Words of the Learned Mr. *Lock*, who thus expresseth himself in his extraordinary Thoughts concerning E D U C A T I O N,

‘ With G E O G R A P H Y, (says he)
‘ C H R O N O L O G Y ought to go
‘ Hand in Hand, I mean the
‘ general Part of it, so that he
‘ may have in his Mind a View of
‘ the whole Current of Time, and
‘ the several considerable *Epochas*
‘ that are made use of in History;
‘ without these two, History, which
‘ is the great Mistress of Prudence
‘ and civil Knowledge, and ought
‘ to be the proper Study of a young
‘ Gentleman, or Man of Business
‘ in the World; without G E O -

G R A P H Y

iv The PREFACE.

GRAPHY and CHRONOLOGY;
 I say, HISTORY will be very
 ill retained, and very little
 useful, but be only a Jumble
 of Matters of Fact, confusedly
 heaped together, without Order
 or Instruction; it is by these,
 that the Actions of Mankind
 are ranked into their proper
 Places of Times and Countries;
 under which Circumstances they
 are not only much easier kept
 in the Memory, but in that na-
 tural Order, are only capable
 to afford those Observations
 which make a Man the better
 for reading them.

ERRATA.

Page 22. Line 20. for *it*, read *which*; p. 34. l. 18. for *Badulgerid*, r. *Bildulgered*; p. 37. l. ult. for *is*, r. *are*; p. 45. l. 11. for *of*, r. *to*; p. 64. l. 23. for *Cofheus*, r. *Cepheus*; p. 65. l. 3. for *Bernices*, r. *Berenices*; p. 79. l. 6. for *Suns*, r. *Moons*; p. 89. l. 16. for *is*, r. *are* p. 102. l. 6. for *furthest*, r. *farthest*; p. 108. for *Ø*, r. *9*; p. 104. l. 20. for 13 r. 11. p. 105. l. 25. for *dichomolised*, r. *dicoheromised*; p. 107. 23. for *is*, r. *will be*; p. 132. l. 12. for *them*, r. *those*; p. 177. l. 10. for *Minutes*, r. *Degrees*; p. 153. l. 5. for *oblique*, r. *obtuse*; p. 162. l. 4. for *Platc* 11. r. *Plate* 10. (Plate 10. and 11. being joined together.)

In the Chronology.

Page 1. for *Compend*, r. *Compendium*? Page 6. Line 6. for *Phrases*, read *Phases*; p. 12. l. 22. for 10 min. r. 5 ho. 10 min. p. 13. l. 7. for *the matter of*, r. *about*; p. 18. l. 9. for *Years*, r. *Centuries*; p. 37. l. 19. for *Characters*, r. *Particulars*.



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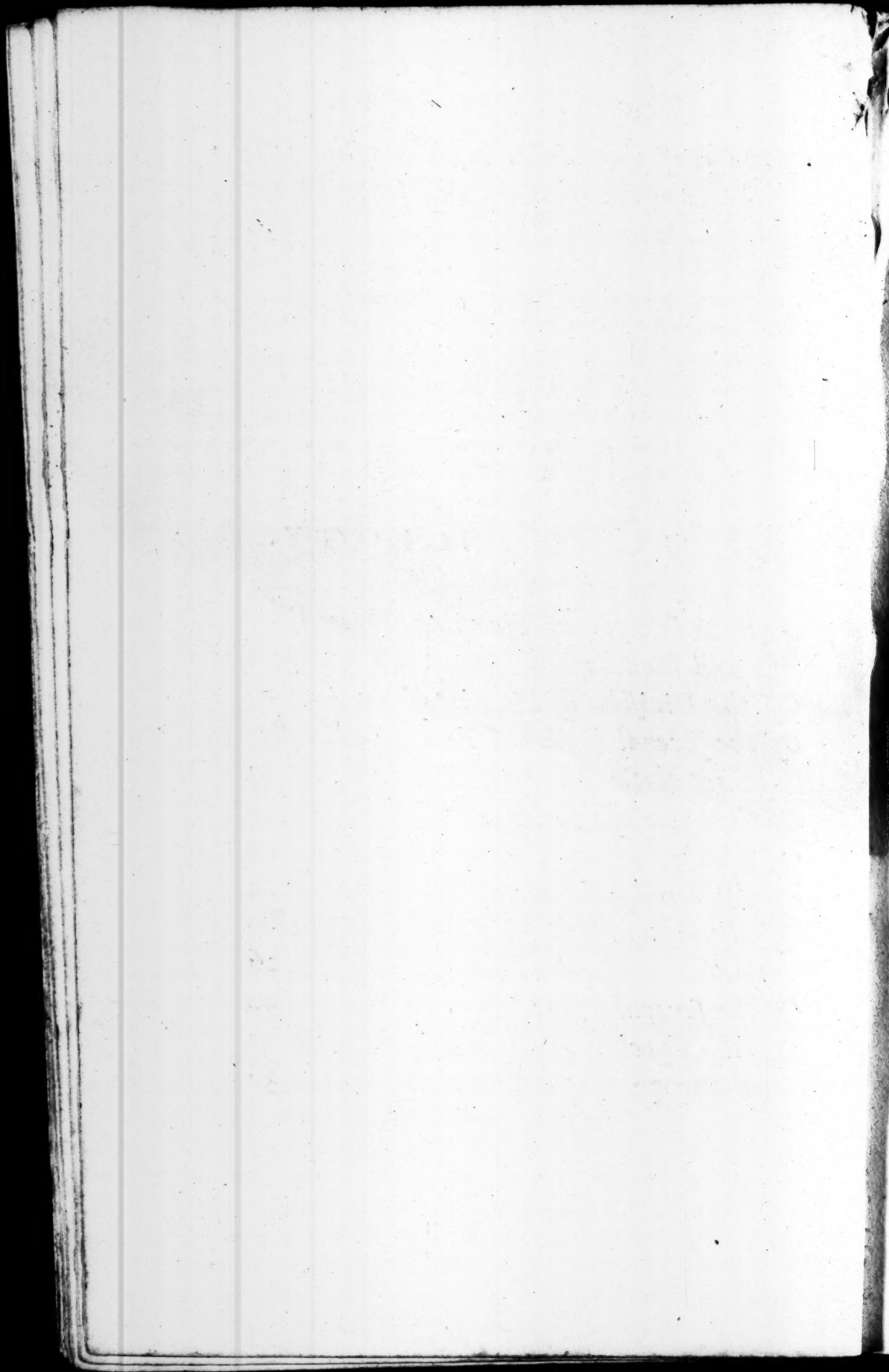
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A
COMPENDIUM
OF
COSMOGRAPHY:

Containing the Principles of G E-
O GRAH HY and A STRONOM Y.

SECT. I.

*Definitions of the Terrestrial
Globe.*

DEFINITION I.



Globe, or *Sphere*, is a round, so-
lid Body, every Part of whose
Surface is equally distant from a
Point within it, called its *Center*, and it
may be conceived to be formed by the
Revolution of a *Semicircle* round its *Dia-*
meter

meter. Every Point in the Circumference of the generating *Semicircle* in its Circumvolution upon its *Axis*, marks out a Circle in the Surface of the *Sphere*; those Circles are greater or lesser, as they are more remote from, or nearer to the Extremities of the *Axis*; that Circle, which is formed by that Point of the *Semicircle*, which is equally distant from the Extremities of the *Axis*, is called, *A great Circle of the Sphere*: All the rest, which are parallel to it, are *Lesser Circles*. Hence all the great Circles of the *Sphere* cut it into two equal Parts; and the lesser, cut it into unequal Parts.

When such a Body as this hath all the Parts of the *Earth* and *Sea*, drawn or delineated on its Surface, like as in a *Map*, and placed in their natural Order and Situation, it is called the *Terrestrial Globe*. But if on its Surface it hath the fix'd Stars, and the Figures of the *Constellations* drawn, 'tis then called the *Celestial Globe*. An Observer placed on this Earth, by extending his Sight every Way equally, if not hindered, bounds the World, by a spherical Surface concentrick with himself (that is with the Earth,) and judges all remote
Objects

Objects, whose Distance is unknown, to be placed as it were in the same Concave Spherical Superficies, tho' they be really very unequally removed from one another. For once then, we shall imagine the *Heavens* and *Earth* to be two concentrick *Spheres*; and then, whatever Circles we suppose in the *Heavens*, we may conceive Circles in the same Position with Relation to one another on this *Earth*: So the same Circles may be described both on the *Celestial* and *Terrestrial* Globes.

The more remarkable great Circles on the Globes are these : *viz.*

- | | |
|-------------------|--------------------------|
| 1. The Equator, | 5. The Equinoctial Co- |
| 2. The Horizon, | lure, |
| 3. The Meridian, | 6. The Solstitial Colure |
| 4. The Ecliptick, | 7. The Vertical Circles. |

The more remarkable lesser Circles are, the two *Tropicks* and two *Polar Circles*.

Def. II. Every Circle is divided, or supposed to be divided into 360 equal Parts, called *Degrees*, and every *Degree* into 60 equal Parts, called *Minutes*. Two Points 90
Degrees

Degrees distant on each Side of any great Circle is called its *Poles*.

Def. III. The *Axis* is an imaginary Line, passing through the real Globe, and is represented in the artificial Globe, by that Wire on which it turns; the Extremities of the *Axis* is the *Poles*, and if the *Axis* be imagined to be extended both Ways, till it reach the *fixed Stars*, it will touch those Points called the *North* and *South Poles*, or the *Arctick* and *Antarctick Poles*.

Def. IV. The *Equator* is a great Circle passing from *East* to *West*, dividing the *Terrestrial* Globe into *Northern* and *Southern* Hemispheres, and the Plane of this great Circle extended every Way, till it meet the fixed Stars, will give us what we call the *Equinoctial* in the *Heavens*; its Poles are the same with the *Poles* of the *World*, as in Fig. 1. where *Æ Q*, represents the *Equator* *P* the *North*, and *P* the *South Poles* of the *World*.

Def. V. The *Horizon* is that great Circle which divides the visible from the invisible

fible *Hemisphere*. When it is considered as a great Circle, it is what we call the *Rational Horizon*: But Geographers call so much of the Earth's Surface as is taken into the Eye (the Eye being turned round to all the Points of the Compass, with the circular Termination of that Vision) by the Name of the sensible *Horizon*. It is a moveable Circle, having the *Zenith*, or Point over the Observer's Head, and the *Nadir*, or Point under the Observer's Feet for its *Poles*.

The *Rational Horizon* is represented by the wooden Circle encompassing the artificial Globe. In the upper Plane whereof are several Circles delineated. The first or inner Circle is divided into 12 equal Parts, representing the 12 Signs of the *Zodiack*, and every Sign is divided into 30 equal Parts, or Degrees, and numbred with 10, 20, 30.

Next to the Circle of Signs is a *Calendar*, according to the Old Style used in *England*, called the *Julian Account*, which is divided into the 12 Months of the Year, every Month being sub-divided into a respective Number of Days, whereunto is annexed the Festival Days. And
by

by Inspection, the Degree of the *Ecliptick* the Sun is in for any Day in the Year may be known.

Next is a *Calendar* of the *Gregorian*, or New Style, now used in most foreign Places, instituted by Pope *Gregory XIII.* in which the Months begin 10 Days sooner than they do in the other.

The last is a Circle of the Winds, divided into 32 equal Parts, called Points of the Compass, by which the *Navigators* design the Quarters of the Heavens, and the Coast and Bearing of Countries. The *Horizon* is represented in Fig. 1. by the Circle H O.

Def. VI. The *Meridian* is a great Circle passing thro' the *Zenith* and *Nadir* and *Poles* of the *Equator*, lying directly *North* and *South* perpendicular to the *Equator* dividing the Globe into the *Eastern* and *Western Hemispheres*; its also a moveable Circle having the *East* and *West* Points for its *Poles*. The artificial Globe is hung in a brazen Circle, which passes through the *Poles* of the *Globe*, that any Point of the *Globe* being brought to that Circle, it may represent the *Meridian* of that Point.

Geographers have fix'd upon one *Meridian*, from which they reckon the Distances of all other *Meridians*, and this they call the *First Meridian*. The *Meridians* usually described on the Terrestrial Globe are 24 *Semicircles*, terminating in the Poles; besides which, we may imagine as many as we please. Upon the brass *Meridian* is fitted a small brass Circle, whose Center is the *Pole* of the Globe, and is divided into 24 equal Parts, representing the Hours of the Day and Night, which in the Revolution of the Globe, are pointed to with an *Index*, which is fitted to the *Pole* of the Globe; its Use is to shew the Time of the rising and setting of the Sun, Moon or Stars, and the Time of Day in any Part of the World.

Def. VII. The *Ecliptick* is a great Circle, cutting the *Equator* at Angles of $23^{\circ} 29'$; therefore the *Poles* of the *Ecliptick* are distant from the *Poles* of the *Equator* in the Solstitial Colure $23^{\circ} 29'$. It is divided into 12 *Signs*, and each *Sign* into 30 Degrees; the Names and Characters of the *Signs* are as follows, viz. Aries γ , Taurus σ , Gemini π , Cancer ϕ , Leo Ω , Virgo

go

go ♉, Libra ♎, Scorpio ♏, Sagittarius ♐
Capricornus ♑, Aquarius ♒, Pisces ♓.

Def. VIII. The *Meridian* which passes through the first of *Aries* and *Libra*, is called the *Equinoctial Colure*; and that which passes through the first of *Cancer* and *Capricorn*, is called the *Solstitial Colure*; the *Poles* of the *Equinoctial Colure* are the two Points where the *Solstitial Colure* cuts the *Equator*, and those of the *Solstitial Colure*, where the *Equinoctial Colure* cuts the *Equator*.

Def. IX. Vertical, or *Azimuth* Circles, are great Circles, perpendicular to the *Horizon*, and passing through the *Zenith* and *Nadir*, as the *Meridians* do thro' the *Poles*. That Vertical which passes through the *East* and *West* Points of the *Horizon*, is called the *Prime Vertical*. These Circles are not drawn on Globes, but are represented by the *Quadrant of Altitude*, which is a thin Plate of plyable Brass, made to skrew on the *Zenith* of any Place, and to reach to the *Horizon*, being divided into 90° , for numbring the Altitude of the Sun or Stars, when they are not on the *Meridian*.

Def. X. Latitude is the Distance of a Place from the *Equator*, and is either *North* or *South*: The brazen *Meridian* is divided into four *Quadrants*, the two upper *Quadrants* are divided, each into 90° , and numbred from the *Equator* to the *Poles*; the other two *Quadrants* are numbred from the *Poles* to the *Equator*. On the two upper *Quadrants*, ; the *Latitudes* of Places are numbred, and on the under *Quadrants* their Distance from the *Poles*, and is represented in Fig. 1. by Z, H, N, O.

Def. XI. Longitude is the Distance of the *Meridian* of any Place, from the first *Meridian*, and is reckoned upon the *Equator*, either *East* or *West* from the first *Meridian*, but seeing the *Meridians* intersect one another in the *Poles*, and all Circles being supposed to be divided into 360 Degrees; It's plain, that a Degree of *Longitude* upon any Parallel of *Latitude*, is of a lesser Extent than a Degree upon the *Equator*, and the nearer you approach to the *Poles*, the lesser they are; therefore the

C

Miles

Miles equal to a Degree of *Longitude* in any *Latitude* may be seen in the following Table.



(II)

*A Table shewing how many Miles go to
a Degree of Longitude in any Parallel
of Latitude.*

Lat.	M.	S.	Lat.	M.	S.	Lat.	M.	S.	Lat.	M.	S.
0	60	00	24	54	48	48	40	08	72	18	32
1	59	56	25	54	24	49	39	20	73	17	31
2	59	54	26	54	00	50	38	32	74	16	32
3	59	52	27	53	28	51	37	44	75	15	32
4	59	5	28	53	00	52	37	00	76	14	32
5	59	46	29	52	28	53	36	08	77	13	32
6	59	40	30	51	56	54	35	26	78	12	32
7	59	37	31	51	24	55	34	24	79	11	28
8	59	24	32	50	52	56	33	32	80	10	24
9	59	10	33	50	20	57	32	40	81	09	20
10	59	00	34	49	44	58	31	48	82	08	20
11	58	52	35	49	08	59	31	00	83	07	20
12	58	40	36	48	32	60	30	00	84	06	12
13	58	28	37	47	56	61	29	04	85	05	12
14	58	12	38	47	16	62	28	08	86	04	12
15	58	00	39	46	36	63	27	12	87	03	12
16	57	40	40	46	00	64	26	16	88	02	04
17	57	20	41	45	16	65	25	20	89	01	04
18	57	04	42	44	36	66	24	24	90	00	00
19	56	44	43	43	52	67	23	28			
20	56	24	44	43	08	68	22	32			
21	56	00	45	42	24	69	21	32			
22	55	36	46	41	40	70	20	32			
23	55	12	47	41	00	71	19	32			

Dif. XII.

Def. XII. All Circles parallel to the *Equator*, on the *Terrestrial* Globe are *Parallels of Latitude*, the most remarkable of which, are the two *Tropicks* and the two *polar Circles*. The two *Tropicks* are those of *Cancer* and *Capricorn*, the former being $23^{\circ} 29'$ distant from the *Equator*, and is represented by φ , Fig. 1. towards the *North*, and the latter at the like Distance towards the *South*, represented by ψ , ψ .

The two *polar Circles* are distant, the one from the *North*, the other from the *South Pole* of the World, $23^{\circ} 29'$. The *North polar Circle* is represented in Fig. 1. by the Line *a b*, and the *South* by *x y*.

Def. XIII. The Earth is divided, in respect of the various Degrees of Heat and Cold into five *Zones*, viz. Two *Frigid*, two *Temperate*, and one *Torrid*. The *Torrid* lies between the two *Tropicks*; the two *Temperate* lie between the two *Tropicks* and *polar Circles*. The two *Frigid*, between the *polar Circles* and the *Poles*. The Inhabitants of the *torrid Zone* are called *Ascii*, because the Noon-Sun, being sometimes exactly over their Heads, they have
no

no Noon-Shade on either Side of them ; the same are called *Amphiscii*, because the Noon Shade falls, some time of the Year, *North* of them, some time *South*. The Inhabitants of the *Temperate Zones* are called *Heteroscii*, having their Noon-Shade only on one Side of them *North* or *South* throughout the whole Year. Such as live in the *Frigid Zones*, are called *Periscii*, because some time of the Year their Shadow hath a circular Motion in 24 Hours, the Sun not setting to them in that Space of Time, but continuing above their *Horizon*, for one, two, &c. or six Months together, according as they are farther from, or nearer to the *Poles*.

Def. XIV The Earth is divided in respect of the various Length of Days into *Climates*. A *Climate* is a Space of the Earth, (parallel to the *Equator*) whose longest Day exceeds the longest Day of the preceeding *Climate* by half an Hour. And whereas the Ancients reckoned but 7 *Climates* on each side of the *Equator*, viz. to 50° 30' *Lat.* there are now reckoned thirty, even up to the *Poles*, according to the following Table : Wherein the Degrees of Latitude
shew

shew the Ends of the *Climates* they are set opposite to, and consequently the Beginnings of the *Climates* immediately following: Thus, the first *Climate* beginning at the *Equator*, ends at $8^{\circ} 25'$ Lat. where the second *Climate* begins and ends at $16^{\circ} 25'$ Latitude, &c.



Climates

Climates.	Quantit. or the longest Day.		Latitude.	
	Hour. Min.		Deg.	Min.
0	12	00	00	00
1	12	30	08	25
2	13	00	16	25
3	13	30	23	50
4	14	00	20	30
5	14	30	36	28
6	15	00	41	22
7	15	30	45	29
8	16	00	49	01
9	16	30	51	58
10	17	00	54	27
11	17	30	56	37
12	18	00	58	29
13	18	30	59	58
14	19	00	61	18
15	19	30	62	25
16	20	00	63	22
17	20	30	64	06
18	21	00	64	49
19	21	30	65	21
20	22	00	65	47
21	22	30	66	06
22	23	00	66	20
23	23	30	66	28
24	24	00	66	21

Months

Months.	1	2	3	4	5	6
Latitud.	67° 15'	69° 30'	73° 20'	78° 20'	84° 10'	90°

It is apparent, that by the foregoing Table, the Length of the longest Day in any Latitude may be easily found. For Example: *Madrid* being in Latitude $40^{\circ} 10'$, it appears by the Table, that it lies within the sixth Climate, and its longest Day is near 15 Hours: Whereas *Stockholm*, in Latitude $59^{\circ} 33'$, lies within the thirteenth Climate, and its longest Day is near 18 Hours and a half.

The Inhabitants of this Earth are also considered with respect to the Position of the *Horizon* with the *Equator*, which is threefold, *viz.* either *Right*, cutting it at right Angles; or it is *Oblique*, or else is *parallel*, and does not cut it at all, but coincides with it. Such as have the first of these Positions, are said to inhabit a right Sphere; such as have the second, an oblique; and such as have the third, a parallel Sphere.

Def. XV. In a right Sphere (namely where the *Equator* *E Q*, is perpendicular to the *Horizon* *H O*, as in Fig. 2.

The

The *Equator* will pass through the *Poles* of the *Horizon*, viz. the *Zenith*, and *Nadir*, and their *Horizon* passes through the *Poles* of the World *PP*, and every Point in the Heavens will seem to ascend right or perpendicularly above the *Horizon*, because it describes a Circle parallel to the *Equator*, which is right or perpendicular to the *Horizon*. All Places upon the terrestrial *Equator* inhabit a right Sphere. Their *Horizon* bisects the *Equator*, and all its Parallels, as is evident by Figure 2.

Therefore their Days and Nights are always equal; all the Stars in both Hemispheres are visible at the *Equator*, and those Stars that rise together, come also to the Meridian together, and set all at the same time, being as long above as below the *Horizon*.

The Amplitude of the Sun and Stars in a right Sphere, are always equal to their Declination: And the right Ascension, oblique Ascension, and oblique Descension in a right Sphere, is the same.

Def. XVI. In a parallel Sphere, where the *Horizon* *H O*, (Fig. 3.) coincides with
D
the

the *Equator* E Q, and the Poles with the *Zenith* and *Nadir*; therefore this Position of the Sphere agrees only with the Inhabitants of the two Poles of the Earth; and all celestial Bodies, that describe Circles parallel to the *Equator* by their diurnal Motion, will likewise describe Circles parallel to the *Horizon*. It's evident by Fig. 3. that the Sun, during its Declination, from the *Equator* towards that Pole which is in the *Zenith*, is always seen, and makes the Day half a Year long; as on the contrary, it's half a Year Night, and that the beginning of the Day and Night falls upon the Sun's Ingress into the *Equinoctial* Points; at either *Pole*, the Stars only of one *Hemisphere* are visible at any time, and those never rise nor set, but constantly describe Circles parallel to the *Horizon*, the other *Hemisphere* of Stars never rise, and therefore not visible to them.

The Altitude of any celestial Phænomenon above the *Horizon* of a Parallel Sphere, is always equal to its Declination from the *Equator*; there is no Ascension or Descension in this Sphere, nor any *Meridian*, since it passes through the *Pole* and *Vertex* of the Place; and since these two coincide

Fig. 2.

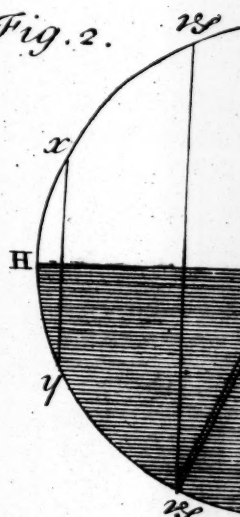


Fig. 1.

Plate 1st

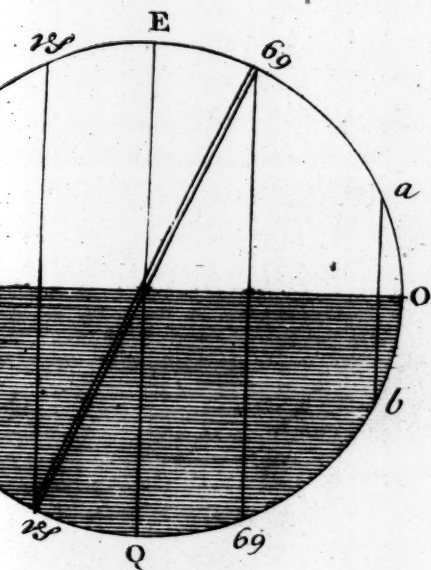


Fig. 3.

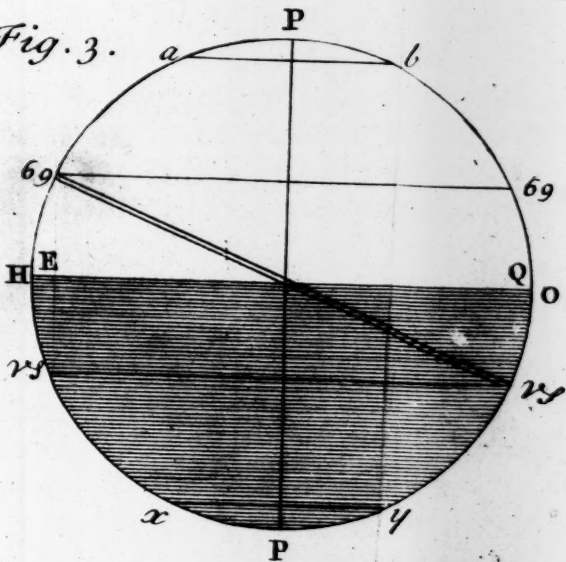
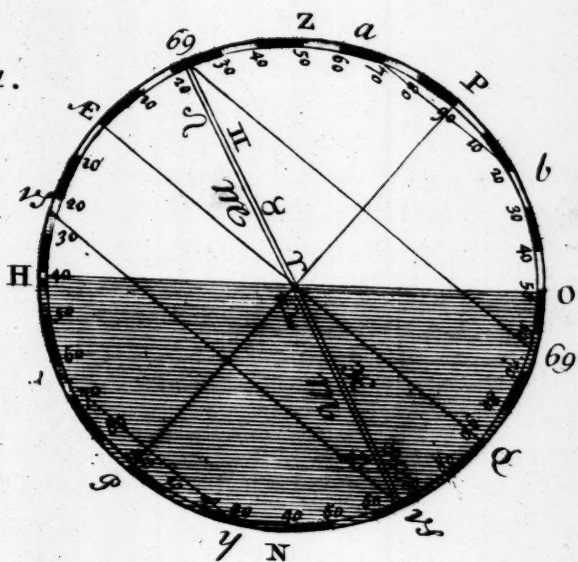


Fig. 1.



cide in this Sphere, they cannot determine the Circle, each Vertical having an equal Right to claim the Name of a *Meridian*. Parallels of Declination, and Parallels of Altitude, are represented by the same Circles in a parallel Sphere.

Def. XVII. It's an oblique Sphere, where the *Horizon* H O (Fig. 1.) cuts the *Equator* E Q, at oblique Angles, and therefore one of the *Poles* of the *Equator*, is elevated above the *Horizon*, and always visible; and the other below the *Horizon*, and always invisible. There are two kinds of this Sphere, for either the North *Pole* is above the *Horizon*, and the South *Pole* depressed, or the contrary. Those who live between the *Equator* and the Arctick *Pole* have the Sphere of the first kind, and those who live between the *Equator* and the Antarctic *Pole*, have the latter. Since each Point in the Heavens, by the diurnal Motion, describes the *Equator*, or some of its Parallels; and only the *Equator*, but not one of its Parallels, is divided into two equal Parts by the *Horizon* of an oblique Sphere. The Sun, and all the Stars that decline to-

wards the visible *Pole*, continue longer above the *Horizon* than below, and on the contrary, such as decline towards the invisible *Pole*, continue hid longer below the *Horizon* than they appear above it; and this holds to a certain Limit towards both *Poles*; for if the Distance of a Star, or celestial Phænomenon, from the visible *Pole*, be less than the Elevation of the *Pole* above the *Horizon*, the Star, or Phænomenon does not set at all, but if its Distance from the invisible *Pole*, be less, it will not rise at all.

All these Phænomena may be explained from the preceeding Diagrams; for it's evident, that in Fig. 2. the *Equator*, and all its Parallels are perpendicular to, and equally divided by the *Horizon*; one half being above, and the other below it. In Fig. 3. the *Equator* coincides with the *Horizon*, and all the Parallels on the North side of it, are above the *Horizon*. And in Fig. 1. all the Parallels to the *Equator* are unequally divided by the *Horizon*, which shews the Variety of the unequal Days and Nights in an oblique Sphere.

Supposing Parallels of Latitude to be drawn through every Degree and Minute of the *Meridian*, which we shall call *sim-*
ply

ply Parallels ; and calling the two opposite Semicircles of the same Meridian, as they are cut off by the Axis of the World, Opposite Meridians, then we may divide the Inhabitants of the Earth into Antæci, Periaeci and Antipodes.

Def. XVIII. Antæci have the same Meridian, but opposite Parallels ; they have Noon and Midnight at the same Time, but opposite Seasons and opposite Poles elevated.

Def. XIX. Periaeci have the same Parallels but opposite Meridians ; they have the same Seasons and the same Pole elevated, but opposite Days and Nights.

Def. XX. Antipodes have opposite Meridians and opposite Parallels, they being diametrically opposite to one another ; they have opposite Seasons, opposite Days and Nights, and opposite Poles elevated.

Having taken a View of the chief Circles belonging to the *Terraqueous* Globe, as also the manner how Latitude and Longitude with *Zones* and *Climates* are numbered, Proceed we next to view its Surface, as composed of Land and Water, as to its
sole

sole constituent Parts, and those two Parts thus subdivided, as follows, *viz.*

Land into	Water into
Continents, Isthmus's,	Oceans, Streights,
Islands, Promontories,	Seas, Lakes,
Peninsulas, Mountains,	Gulfs, Rivers.

Def. XXI. A *Continent* is a large continued Space of Land, containing many Countries and Kingdoms; and consequently not easily discernible to be surrounded with the Sea. It is also called *The Main*, or *Firm Land*.

Def. XXII. An *Island* is a smaller Tract of Land, which more plainly appears to ly in the Sea.

Def. XXIII. A *Peninsula* is a Part of Land, which is almost an *Island*, being encompassed with the Sea; but where it's joined to the *Continent* by some narrow Neck of Land, it is called an *Isthmus*.

Def. XXIV. A *Promontory*, or *Cape* is a Mountain, or some considerable Eminence shooting out into the Sea. If the Land shooting

shooting out, be level, or hath no considerable rising, it is call'd a *Point*.

All the vast Assemblage, or Body of salt Water in general, is call'd *Sea*, which Name is also promiscuously applied to any of its following Parts.

Def. XXV. The *Ocean* is the wide open Part of the *Sea*, lying without the Land.

Def. XXVI. A *Gulf* is an Arm or Branch of the *Sea*, received as it were into the Bosom of the Earth. Lesser *Gulfs* are term'd *Creeks*, *Bays* and *Roads*.

Def. XXVII. A *Streight* is a narrow Part of the *Sea*, pent up, for the most part, between two Promontories, and joyning some *Gulf* to the *Ocean*, or two Seas to one another.

Def. XXVIII. A *Lake* is a great Collection of Water, which hath no Communication with the *Sea*, but by some *River*, or subterraneous Passages. A *Morass* differs from a *Lake*, in that it is not always full of Water, or at least may be drain'd.

As

As for *Rocks, Hills, Mountains, Val-
lies, &c.* as also (the Terms of fresh Wa-
ter) *Rivers, Brooks, Springs, &c.* they
need no Explanation.



SECT. II.

Of the general Divisions of the Terraqueous Globe.

THE *Terraqueous* Globe is made up
of two general Parts, the *Earth* and
Sea. I shall begin with a Description of
the latter, as encompassing the former.

It was distinguished by the *Ancients* in-
to the *Northern, Southern, Eastern* and
Western Oceans; and although the same
Distinction might still serve, yet another
Continent, besides that anciently known,
having been since discovered, which is so
situated, that the old *Western Ocean* is its
Eastern, and on the contrary; it seems
more commodious to call the *Sea*, lying
between the *Western Coast* of the old
Continent

Continent and the *Eastern* Coast of the new Continent, by the Name of the *Atlantick Ocean*, the same being taken from the famous Mount *Atlas* on the *Western* Shore of *Africk*; and in like manner to call the Sea, lying between the *Eastern* Coast of the old Continent, and the *Western* Coast of the new Continent, by the Name of the *pacifick Ocean* (in respect of the great Tranquillity generally observed by Sea-Men, and the Freedom from Tempests of any kind, in a great Part of it, particularly on the Coast of *Peru*) or of the *Indian Ocean*, for as much as it lies between the *East* and *West Indies*.

The *Northern* and *Southern Oceans* retain their Names from their Situation, with respect to the *Poles*.

Each *Ocean*, or *General Sea* (as formerly, so now) is distinguished into lesser Seas or *Gulfs*, &c. by several Denominations (taken for the most part) from Countries lying adjacent to them. The chief of the inland Seas are, *viz.*

The *Baltick Sea*, being bounded with *Sweden* on the *West*, and *Poland* and *Germany* on the *East* and *South*.

The *German Sea* enclosed with *Scandinavia* on the *East*, and *Great Britain* on the *West*.

The *Irish Sea*, lying between *Ireland* and *England*.

The *Mediterranean Sea*, bounded by *Europe* on the *North*, and *Africa* on the *South*.

The *Euxine Sea*, enclosed with Part of *Europe* on the *North* and *West*, and Part of *Asia* on the *South*.

The *Caspian Sea* lying in *Asia*.

The Earth, the other Part of the *Terraqueous Globe*, may be divided into four Parts, two whereof are known, the one anciently lying *Eastward* in respect of our *Hemisphere*, call'd therefore the *Eastern*, or *old Continent*; the other lately, lying *Westward*, and from thence call'd the *Western*, or *new Continent*; the two remaining Parts being but little discovered, are said to be *unknown*, and from their particular Situations, the one is call'd the *Northern*, and the other the *Southern unknown Continent*.

I shall first treat of the *Eastern*, or *old Continent*, the Division whereof into three Parts, viz. *Europe*, *Asia*, and *Africa*, has
 2 been

been generally received, it being in all probability, made as soon as the Ancients came to have a compleat Knowledge of the Course of the *Mediterranean* and *Red Seas*, by the Interflux of which two, Nature hath given sufficient Directions for such a Tripartition.

And here it may not be unuseful to observe, that whereas, *Europe*, *Asia*, and *Africa*, may now-a-days most properly be look'd upon as making one *Continent*, the Ancients esteem'd them as three distinct *Continents*, giving to all three considered together, the Name of *World*; forasmuch as all they knew of the *World* comprehended no more than what they knew of these three, which was much less than what now goes under the same Name, and scarce a fourth Part of what is at present known of the whole World.

And thus much for the general Divisions of the *Terraqueous* Globe, as also of the *old Continent*. I now proceed to a more particular Description of the Globe, as divided into *Europe*, *Asia*, *Africa* and *America*.

Of the Divisions of EUROPE.

Europe is bounded to the *Northward* by the *Northern Ocean*; *Westward*, partly by the *Northern*, and partly by the *Atlantick Oceans*; *Southward*, by the *Streights of Gibraltar* and the *Mediterranean Sea*, by which it's parted from *Africa*; and on the *East*, it's parted from *Asia* by the *Archipelago* or *Ægean Sea*, *Streights of the Dardanel*s, *Sea of Marmora* or *Propontis*, *Streights of Constantinople*, *Black Sea* or *Pontus Euxinus*, *Streights of Caffa*, *Sea of Zaback* or the *Palus Meotis*, the *River Don* or *Tanais*.

The

The *European* Continent is divided into

Portugal,	} Chief Towns	<i>Lisbon.</i>
Spain,		<i>Madrid.</i>
Italy,		<i>Rome.</i>
Turky,		<i>Constantinople.</i>
France,		<i>Paris.</i>
Germany,		<i>Vienna.</i>
Poland,		{ <i>Cracow, and</i>
Hungary,		{ <i>Warsaw.</i>
Switzerland,		<i>Buda.</i>
Little Tartary,		{ <i>Basil, and</i>
Nether- } United,		{ <i>Geneva.</i>
lands } Spanish,		<i>Caffa.</i>
Muscovy,		<i>Amsterdam.</i>
Sweden,		<i>Brussels.</i>
Denmark,		<i>Muscow.</i>
Norway.		<i>Stockholm.</i>
		<i>Copenhagen.</i>
		<i>Bergen.</i>

The

The chief of the *European* Islands are

Great Britain,	{ England,	Chief Towns	{ London,
Ireland,	{ Scotland,		{ Edinburgh.
Iceland,			{ Dublin.
Sicily,			{ Shalbolt.
Sardinia,			{ Palermo.
Corfica,			{ Cagliari.
Candie,			{ Bastia.
			{ Candia.

The most remarkable *Mountains* are, the *Pyrenean*, which divide *France* from *Spain*; the *Alps*, which lie between *France*, *Germany*, and *Italy*; the *Apennine*, running along the midst of *Italy*; the *Crapack*, between *Poland* and *Hungary*; the *Dofrine*, between *Norway* and *Sweden*; *Stramboli-volcano*, in an Island West of *Naples*; and *Ætna*, in *Sicily*.

The most remarkable *Rivers* are, the *Wolga* and *Dwina* in *Muscovy*; the *Don* or *Tanais*, in *Little Tartary*; the *Nieper*, and *Weyffel*, in *Poland*; the *Danube*, *Rhine*, and *Elbe*, in *Germany*; the *Thames*, and *Severn*, in *England*; the *Loire*, *Garonne*, and *Rhosne*, in *France*; the *Po*, and *Tyber*,
in

in *Italy*; the *Ebro*, and *Tagus*, in *Spain*, and *Portugal*.



The Divisions of ASIA.

IT is bounded *Eastward* by the *Eastern*, or *pacifick Ocean*, lying between it and *America*, *Southward* by the *Indian Ocean*; *Westward*, it is separated from *Africa* by the *Red Sea*; the *Mediterranean Sea* and the *Isthmus*, lying between them: From *Europe*, by the Bounds already mentioned in the Description of *Europe*.

It is divided into

Great Tartary,	} Chief Towns	<i>Astracan,</i>
Georgia,		<i>Teflis.</i>
China,		<i>Pekin.</i>
The two Penin-		<i>Goa, in the West</i>
fulas of India,		<i>Peninsula.</i>
or the E. Indies		<i>Pegu in the Eastern</i>
Empire of the		<i>Agra.</i>
Mogul in the		<i>Ispahan.</i>
East Indies.		<i>Bagdat, formerly</i>
Persia,		<i>Babylon.</i>
Turky in Asia,	}	<i>Medina, Mecca.</i>
Arabia,		Among

Among the *Asiatick* Islands the chief are

In the { *Eastern Ocean*, the Japan Isles.
Indian Ocean, Sumatra, Java, Borneo, Ceylon.
Mediterranean-sea, Cyprus, Rhodes
Egean Sea or *Archipelago*, Scio, Same, Metelin.

The chief Mountains of *Asia* are *Taurus*, beginning in *Pamphylia* a Province in *Asia minor*, runs *Eastward* through all *Asia*; the *Imaus* lying in *Scythia* or great *Tartary*, and *Caucasus*, lying between the *Euxine* and *Caspian* Seas.

The chief Rivers are the *Ganges* and *Indus* in the *East-Indies*, the *Tigris* and *Euphrates* both rising in *Armenia*, and running into the *Caspian* Sea, and the *Oby* in *Great Tartary*.

The Division of AFRICA.

Africa is a *Peninsula*, being joyned to the rest of the *Continent* only by a small Neck of Land, now called the *Isthmus* of *Suez*.

It is bounded on the *North* by the *Mediterranean* Sea; *Eastward* by the fore-mentioned *Isthmus* and the *Red-sea*; *South*, by the *Ethiopian* or *Southern Ocean*; and *West*, by the *Atlantick Ocean*.

It is divided into

Egypt,			Cairo,
<i>Barbary</i> con-	{ Barca,		<i>Barca</i> ,
tain-	{ Tripoli,		<i>Tripoli</i> ,
ing	{ Tunis,		<i>Tunis</i> .
	{ Algiers,		<i>Algiers</i> .
Beldulgered,	{ Morocco,		<i>Morocco</i> .
Zara, or the De			<i>Dara</i> .
fart,			<i>Zuenziga</i> .
Negroland,			<i>Tombate</i> .

Guinee,	Chief Towns	<i>Arda.</i>
Nubia,		<i>Duncala.</i>
Congo,		<i>St. Salvador.</i>
Monomotapa,		<i>Monomotapa.</i>
Zanguebar,		<i>Mosambique.</i>
Caffares,		<i>Cape of Good Hope.</i>

The most considerable Isles belonging to *Africa* are

Madagascar,
Cape de Verde Islands,
Canary Islands,
Madera Islands,
Azore Islands,
Malta, in the Mediterranean.

The chief Mountains of *Africa* are, Mount *Atlas*, running from the *Western Ocean* to *Egypt*, and separating *Barbary* from *Bedulgerid*, the Mountains of the *Moon*, spreading themselves over the most of the *South Part of Africa*; to which may be added the *Peak of Teneriff*, in the Island of *Teneriff*, esteemed one of the highest in the Universe.

Among the several Rivers, the two chief are the *Niger* and *Nile*; the *Niger* running through *Negroland*, and emptying it
self

self into the *Atlantick Ocean*, on each side of *Cape de Verde*.

The *Nile* runs through the Middle of *Egypt*, emptying it self into the *Mediterranean Sea*, formerly by seven Mouths, of which four only now remain; and of these the *Eastern* and the *Western* only are navigable.



*The Divisions of AMERICA, or
the NEW CONTINENT.*

*A*merica is divided into two general Parts, commonly called *North* and *South America*, which are two very large *Peninsula's* separated the one from the other by the *Isthmus* of *Darien*, or *Panama*.

North *America* is divided into

New France,	} Chief Towns	<i>Quebeck.</i>
New England,		<i>Boston.</i>
New York,		<i>New York.</i>
New Jersey,		<i>Elizabeth Town.</i>
Pensilvania,		<i>Philadelphia.</i>
Maryland,		<i>St. Mary's.</i>
Virginia,		<i>James Town.</i>
Carolina,		<i>Charles Town.</i>
Florida,		<i>St. Austin.</i>
New Mexico, or }		<i>St. Fé.</i>
New Granada, }		
New Spain,		<i>Mexico.</i>

South

South *America* contains

Terra Firma,	} Chief Towns	Panama.
Peru,		Lima.
Chili,		St. Jago.
Magellanica,		Nombre de Jesus.
Paraguay,		Buenos Ayres.
Brazil.		St. Salvador.

Country of the *Amazons* very little known to us *Europeans*.

The most remarkable Islands belonging to *America*, are

Newfound-land, over-against *New France*, *Bermudes*, or *Sumnaers-Isles*, being reckoned about 400, lying South of *Newfound-land*, and over-against *Carolina*.

Lucay, or *Bahama Isles*, South West of *Bermudas*, nigh the Coast of *Florida*.

Antille-Isles lying South of the former, of which the four greatest are

Cuba, *Jamaica*, *Hispaniola*, and *Porto-rico*.

Caribbee-Islands, lying South-East of *Porto-rico*, the most remarkable of them, is *Barbadoes*, chief Town, *Bridge-Town*.

California

California, esteemed the largest Island in the World, though some will not allow it to be an Island, it lies on the West Coast of *New Mexico*.

The chief Mountains of *America*, are the *Andes*, or *Cordilleras*, spreading themselves over great Part of *South America*; the *Alpaches* N. of *Florida*, in N. *America*, to which may be added the numerous *Vulcano's* on the Western Coasts and inland Parts of the Kingdom of *Mexico*.

The chief Rivers of *North America* are *Canada*, in *New France*, and *Mississippi* in *Louisiana*. Of *South America*, the River of the *Amazons*, esteemed the largest in the World; *Rio de la Plata* in *Paraguay*; *Oronoque* in *Terra Firma*.

SECT.

S E C T. III.

Containing some pleasant Geographical PROBLEMS.

P R O B L E M I.

To find the Latitude and Longitude of Places.

Bring the Place whose *Latitude* and *Longitude* you would know, to the brazen *Meridian*, and the Number of Degrees contained between the *Equator* and the Place, is the *Latitude*; and the Degrees of the *Equator*, between the first *Meridian* and the East-side of the brazen *Meridian*, is the *Longitude*.

Example.

To know the *Latitude* and *Longitude* of *London*; bring the Mark for *London* to the brazen *Meridian*, and number the Degrees of the *Meridian* from the *Equator* to *London*, which is $51\frac{1}{2}$ for the *Latitude*.

If

If the *Longitude* be numbred from the *Meridian* of *London*, it will have no *Longitude*; for when *London* is at the brazen *Meridian*, 'twill cross the *Equator*, where the *Longitude* begins, but if it be numbred from any other Place, where the brazen *Meridian* crosseth the *Equator* is the Degree of *Longitude* numbred from the first *Meridian*.

P R O B. II.

The Day of the Month being given, to find the Sun's Place in the Ecliptick.

Find the Day of the Month in the Circle of Months upon the *Horizon*, and right against it in the Circle of Signs is the Degree of the *Ecliptick* for that Day.

Example.

I demand the Sun's Place in the *Ecliptick* for *April* 20th.

First, find the 20th of *April* in the *Julian* Account, which is the innermost Circle of Months, and against it in the Circle of Signs is the 11th Degree of *Taurus*, which is the Sun's Place for that Day.

PROB

P R O B. III.

To rectify the Globe.

Find the *Latitude* of the Place for which you would rectify it, by *Problem I.* and if it be in *N. Lat.* elevate the *N. Pole* above the *N. Point* of the *Horizon*, then find the *Sun's Place* by *Prob. 2.* Mark it in the *Ecliptick*, and bring it to the *Meridian*, then set the *Horary Index* at the uppermost 12, on the *Hour-Circle*; next screw the *Quadrant of Altitude* in the *Zenith* that is over the *Latitude* of the Place, and place the *Meridian North and South*, which you may do by the *Needle* on the *Horizon*; for you must turn the *Globe* till the *Needle* point just to the *Fleur-de-lys*, then is the *Globe* rectified.

P R O B. IV.

A Place being given, to find all those Places that have the same Latitude and Longitude.

Bring the Place to the brazen *Meridian*, then all those Places lying under that *Semicircle* have the same *Longitude*, and if

G

you

you hold a Pencil at the *Latitude* of the Place, and turn the Globe round, all the Places which pass under the Pencil have the same *Latitude*.

P R O B. V.

The Day of any Month being given, to find the Length thereof in any Latitude.

Elevate the Globe for the *Latitude*, and mark the Sun's Place in the *Ecliptick*, which bring to the brazen *Meridian*, and set the *Index* to the uppermost 12 on the Horary Circle; then turn the Globe *Eastward*, till the Sun's Place be at the *Horizon*: The *Index* points out the Hour of Sun-rising; then turn the Globe, till the Sun's Place come to the *West Side* of the *Horizon*, and the *Index* will point out the Hour of Sun-setting; the double of the Hours of Sun-setting is the Length of the Day; and the Time of Sun-rising doubled, gives the Length of the Night.

P R O B. VI.

The Latitude being given, to know the Length of the longest and shortest Days.

Elevate the Globe according to the *Latitude*, and for the longest Day, if it be in *North Latitude*, mark the first Degree of *Cancer* on the Globe, and work as in *Problem 5.* for the shortest Day, take the first Degree of *Capricorn*, and do as in *Prob. 5.* But if the Place be in *South Latitude*, the Sun is in the first of *Capricorn* on the longest Day, and in the first of *Cancer* on the shortest. This Problem serves only to find the Length of the longest Days in the Temperate and Torrid Zones.

C1

P R O B. VII.

Any Place being given in the Frigid Zones, to know how long the Sun shines in that Place without setting.

Elevate the Globe, according to the *Latitude* of the Place, then turn the Globe till the first of *Cancer* come under the *Meridian*, and count the same Number of Degrees upon the *Meridian* from each side of the *Equator*, as the Place is distant from the Pole, and making a Mark where the Reckoning ends, turn the Globe round, carefully observing what two Degrees of

G 2

the

the *Ecliptick* pass exactly under the two Points marked in the *Meridian*; for the *Northern Arch* of the Circle being reduced to Time, will give the Number of Days that the Sun doth shine above the *Horizon* of the given Place, and the opposite Arch of the same Circle will give the Number of Days in which he is absent.

P R O B. VIII.

Any Place being given, to know its Antæci, Periæci and Antipodes.

For the *Antæci*, bring the given Place to the brazen *Meridian*, and find its *Latitude* by *Problem 1.* Then count on the *Meridian* as many Degrees on the other side of the *Equator*, as the Place has Latitude, and the Point of the Globe directly under the last of those Degrees is the *Antæci* of your Place.

For the *Periæci*, bring the given Place to the upper, or South *Meridian*, and the Point under the same Parallel on the North *Meridian*, is the *Periæci* of the given Place.

For

For the *Antipodes*, bring the given Place to the *North Point* of the *Horizon*, and that Part of the Globe at the *South Point* of the *Horizon* is the *Antipodes* required.

PROB. IX.

The Day and Hour being given, to find those Places of the Globe to which the Sun is in the Meridian at that time.

The *Pole* being elevated according to the *Latitude* of the given Place, bring that Place of the brazen *Meridian*, setting the *Index* of the *Horary Circle* to the Hour of the Day; then turn the Globe, till the *Index* point to the upper Figure of 12, then fix the Globe in that Situation, and all those Places under the upper half of the brazen *Meridian*, have the Sun in their *Meridian* at that particular time.

PROB. X.

The Day and Hour being given, to know what a Clock it is in any Part of the World.

Elevate the Globe to the *Latitude* of the Place you are in, and set the *Index*

to

to the given Hour, then turn the Globe, till the proposed Place come to the brazen *Meridian*, and the *Index* will point out the Hour required.

P R O B. XI.

To find the Difference of Time between any two given Places.

Bring one of the Places to the brazen *Meridian*, and set the *Index* to 12, then turn the Globe till the other Place come to the *Meridian*, and the *Index* points out the Difference of Time.

The Difference of Time being known, and the Time of the Day in one, the Time of the Day in the other may be known thus, If the Place, whose Time is required, be to the *East* of the other Place, where the Time is known, add the Difference of Time to the given Time, the Sum will be that required ; but if it be to the *West*, subtract the Difference of Time from the Time given, and the Remainder will be the Time required.

P R O B.

P R O B. XII.

A Place being given on the Globe, to find those which have the same Hours of the Day with that in the given Place, as also to know where all the 24 Hours exist at one and the same time.

Bring the given Place to the brazen Meridian, and set the Index to the Hour, then observe what Places are under the Semicircle of that Meridian; for the People in these Places have the same Hour with the given Place. Which suppose 12, then those that lie 15 Degrees East, have one a Clock; 30 Degrees, two a Clock; 45 Degrees makes three a Clock. And by turning the Globe round, when the Index points at the several Hours, observing the Places lying under the upper Circle of the brazen Meridian, you may mark out with Chalk the 24 Meridians, where the 24 Hours exist, at one and the same time.

P R O B.

P R O B. XIII.

A Place being given in the Torrid Zone, to find those Days in which the Sun shall be Vertical to the same.

Bring the given Place to the brazen *Meridian*, and mark the Degree of *Latitude* above it; move the Globe round, and observe the two Points of the *Ecliptick* that pass through the said Degree of *Latitude*, search upon the wooden *Horizon* for those two Degrees, and opposite to them you will find the two Days on which the Sun is Vertical at the given Place.

P R O B. XIV.

To know the Climate of any Place.

Find the Length of the longest Day for the given Place, by *Prob. 6.* and the Number of Hours it exceeds 12, the double of which Excess gives the *Climate* of the Place desired. But this Rule serves only for the *Torrid* and *Temperate Zones*; for if the Place, whose *Climate* is required, lie in either of the *Frigid Zones*, with the
Latitude

Latitude of the given Place, enter the Table of *Climates*, and opposite to the *Latitude* you will have the *Climate* required.

P R O B. XV.

The Place of the Sun given, to find his Declination.

Bring the Degree of the *Ecliptick* the Sun is in, to the brazen *Meridian*, and the Degrees of that *Meridian* intercepted between the *Equator*, and the Degree of the *Ecliptick* the Sun is in, is his Declination for that Day; and bears the Denomination of *North* or *South*, according to its Position on the *North* or *South-side* of the *Equator*.

P R O B. XVI.

The Place of the Sun given, to know his Meridian Altitude.

Rectify the Globe, bring the Degree of the *Ecliptick* the Sun is in, to the brazen *Meridian*, and the Number of Degrees contain'd between the *Horizon*, and the Sun's Place on the *Meridian*, is the Num-

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ber of Degrees that the Sun is elevated above the *Horizon* at Noon.

P R O B. XVII.

The Sun's Place being given, to find his Amplitude, and upon what Point of the Compass he riseth.

Rectify the Globe, bring the Sun's Place to the *East-side* of the *Horizon*, and the Number of Degrees intercepted betwixt the *East-point* of the *Horizon* and the Sun's Place, is the Number of Degrees of *Amplitude* at Sun-rising, and bears the Denomination either of *North* or *South*, according to its Inclination to either Point in the *Horizon*. Or if you would know upon what Point of the Compass the Sun rises, look in the outermost Circle upon the *Horizon*, which is the Circle of *Winds*; and against the Sun's Place, you have the Name of the Point of the Compass upon which the Sun riseth.

P R O B.

P R O B. XVIII.

The Day of the Month, and the Hour of the Day given, to find the Height of the Sun in any given Latitude.

Rectify the Globe, then turn it about till the *Index* point to the Hour of the Day, then bring the *Quadrant of Altitude* to the Sun's Place in the *Ecliptick*, and the Degree of the *Quadrant* which touches the Sun's Place, shall be the Number of Degrees of the *Sun's Altitude*.

P R O B. XIX.

The Altitude of the Sun, and Day of the Month given, to find the Hour of the Day.

The Globe rectified, bring the Place of the Sun to the Number of Degrees of *Altitude*, accounted upon the *Quadrant of Altitude*, and the Hour-Index will point at the Hour, in the Hour Circle.

P R O B. XX.

To know when the Morning Twilight begins, and when the Evening Twilight ends.

Rectify the Globe, bring the Sun's Place to the upper *Meridian*, then the Degree of the *Ecliptick*, which is opposite to the Sun's Place, will be on the lower *Meridian*, which mark with a *Pencil*; then turn the Globe, till the Degree opposite to the Sun's Place be elevated 18 Degrees in the *Quadrant of Altitude* above the *Horizon* in the *West*, so shall the Sun's Place be depressed 18 Degrees below the *Eastern Horizon*, and the *Hour-dex* will point out the Hour, that the Morning-Twilight begins, which subtract from the time of Sun-rising, the Remainder is the Continuation of the Morning Twilight. Then for the Evening-Twilight, after the Globe is rectified by *Prob. 3.* bring the Degree of the Sun's Place 18 Degrees above the *East-side* of the *Horizon*, measured on the *Quadrant of Altitude*, then will the Sun's Place be depressed 18 Degrees below the *Western-side* of the *Horizon*, the *Index* will point out

out the time of Sun-setting, from the ending of the Evening-Twilight, the Remainder will be the Continuation of the Evening-Twilight.

P R O B. XXI.

A Place being given on the Globe, to find its Bearing from any other Place.

Bring the given Place to the brazen *Meridian*, and elevate the *Pole* according to its *Latitude*, and fixing the *Quadrant* of *Altitude* in the *Zenith*, apply the same successively to any of the Places whose Bearing is desired, the *Quadrant* will intersect the wooden *Horizon* at those various Points of the Compass, upon which those Places bear in respect of the given Place.

P R O B. XXII.

A Place being given on the Globe, to find all other Places that are situated from the same upon any desired Point of the Compass.

Elevate the *Pole* according to the *Latitude* of the given Place, bring the said Place to the brazen *Meridian*, and fix the *Quadrant*

drant of Altitude in the Zenith, apply the Quadrant to the desired Point of the Compass upon the wooden Horizon, and observe what Places are under the graduated Edge of the said Quadrant, for those are the Places desired.

P R O B. XXIII.

The Day, and Hour of the Day being given, to find those Places on the Globe, in which the Sun then riseth. 2. Those in which he then setteth. 3. Those in which it's Mid day. And, lastly, those Places that are actually enlightned, and those that are not.

Find that Place of the Globe, to which the Sun is vertical at the given time, by Prob. 13. and bringing the same to the brazen Meridian, elevate the Pole according to the Latitude of the said Place. The Globe being fixed in that Position, observe what Places are in the Western Semi-circle of the Horizon, for in them the Sun riseth at that time. 2. Those in the Eastern Semi-Circle, for in them the Sun setteth. 3. Those that are exactly under the brazen Meridian, for in them it's Mid-day.

day. And lastly, all those upon the upper *Hemisphere* of the Globe, for they are actually enlightned, and those upon the lower are in Darknes, or deprived of the Sun at that very time.

P R O B. XXIV.

The Day and Hour of either a Solar or Lunar Eclipse being known, to find by the Globe all those Places, in which the same will be visible-

Mark the Sun's place in the *Ecliptick* for the given Day, as also the opposite Point thereto, which is the Place of the Moon at that time. Then find that Place of the Globe to which the Sun is vertical at the given Hour, by *Prob. 13.* and bring the same to the *Zenith* (or the Vertical Point) of the wooden Horizon, and fixing the Globe in that Situation, observe what Places are in the upper *Hemisphere*, for in most of them will the Sun be visible, during the time of the *Eclipse*. As for the *Lunar Eclipse*, you are to find the *Antipodes* of that place, which hath the Sun Vertical at the given Hour, and bringing the same to the Pole of the wooden

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en *Horizon*, observe what Places are in the upper *Hemisphere* of the Globe, for in such will the Moon be visible during her Eclipse, except those near, or in the *Horizon*.

PROB. XXV.

The Hour of the Day being given, according to our Way of reckoning in England, to find thereby the Babylonick Hour at any time.

The *Babylonick Hour* is the Number of Hours from Sun-rising, it being the manner of the *Babylonians* of old, and the Inhabitants of *Norimberg* at this Day, to commence their Hours from the Appearance of the Sun in the *Eastern Horizon*. For the finding of this Hour at any time or in any place: First, elevate the Pole to the Latitude of the given Place, and mark the Sun's Place in the *Ecliptick* at that time, bring the same to the brazen Meridian, and set the Index of the *Horary-Circle* at Noon, then move the Globe either Eastward or Westward, according to the time of the Day, till the Index point at the given Hour. Then fix the Globe in
that

that Position, and bring back the *Index* again to Noon, and move the Globe from West to East, till the Sun's Place mark'd in the *Ecliptick*, coincide with the Eastern *Horizon*, which done, reckon upon the Hour Circle, the Number of Hours between the *Index* and Noon (or the upper Figure of 12.) for that is the Number of Hours, from Sun-rising for that Day, in the given Place, or the true *Babylonick Hour* desired.

PROB. XXVI.

The Babylonick Hour being given, to find the Hour of the Day at any time, according to our way of Reckoning in England.

Elevate the *Pole* to the *Latitude* of the given Place, and marking the Sun's Place in the *Ecliptick*, bring the same to the brazen *Meridian*, and set the *Index* of the Horary-Circle at Noon. Then move the Globe *Westward*, till the *Index* point at the given Hour from Sun-rising, and fixing the Globe in that Situation, bring the *Index* back again to Noon, and turn the Globe backwards, till the Sun's Place mark'd in

the *Ecliptick*, return to the same Semicircle of the brazen *Meridian* from whence it came ; which done, observe what Hour the Index of the Horary-Circle pointeth at, for the same is the Hour desir'd.

P R O B XXVII.

The Hour of the Day being given, according to our Way of reckoning in England, to find thereby the Italick Hour at any time.

The *Italick Hour* is the Number of Hours from Sun-setting at all Times of the Year, to Sun-setting the next following Day. For finding of which, elevate the Pole according to the *Latitude* of the Place, and noting the Sun's Place in the *Ecliptick* for the given Day, bring the same to the brazen *Meridian*, and set the *Index* of the Horary Circle at Noon, then turn the Globe either *East* or *West*, according to the Time of the Day, till the *Index* point at the given Hour, and fixing the Globe in that Position, bring the *Index* back to Noon. Which done, turn the Globe *Eastwards*, till the Mark of the Sun's Place in the *Ecliptick* coincide with the
Western

Western Horizon ; and observe how many Hours are between the upper Figure of 12 and the Index (reckoning them *Eastward* as the Globe moved) for these are the Hours from Sun-set, or the *Italick Hour* desired.

P R O B. XXVIII.

The Italick Hour being given, to find thereby the Hour of the Day at any Time, according to our way of reckoning in England.

Elevate the Pole to the *Latitude* of the given Place, and noting the Sun's Place in the *Ecliptick*, bring the same to the *Western Horizon*, and setting the *Index* of the Horary Circle at Noon, turn the Globe *Westward*, till the *Index* point at the *Italick Hour* given ; then fixing the Globe in that Position, bring the *Index* back to Noon, and move the Globe *Eastward*, till the Mark of the Sun's Place come to the *E.* Side of the brazen *Meridian*. Which done, observe how many Hours are between Noon and the *Index* (reckoning them from *West* to *East*) for those are the Hours desired,

according to our Way of reckoning in *England*.

P R O B. XXIX.

The Hour and Day being given, according to our Way of reckoning in England, to find thereby the Judaical Hour at any time.

The *Jews*, in reckoning their Time, divide the artificial Day into 12 Hours, and the Night into as many, which Hours prove every Day unequal in Extent (unless in Places exactly under the *Equator*) they still increasing or decreasing according to the Seasons of the Year, or the various Declination of the Sun.

For the finding of which Hours, observe the following Method : Elevate the *Pole* according to the *Latitude* of the given Place, and marking the Sun's Place in the *Ecliptick* at that Time, bring it to the *Eastern Horizon*, and set the *Index* of the Horary-Circle at Noon ; then turn the Globe about, till that Place marked in the *Ecliptick* come to the *Western Horizon*, and observe the Number of Hours between Noon and the *Index*, these being the Hours
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of which the given Day doth consist, which Number you are to take notice of, and to find what Hour from Sun-rising corresponds with the given Hour, or from Sun-setting, if the given Hour be after Sun-setting. Which done, work by the following Proportion. As the Number of Hours, whereof the given Day consisteth (*viz.* those set down) is to 12: So is the Number of Hours from Sun-rising (if it be an Hour of the Day) or from Sun-setting (if an Hour of the Night) to a fourth Proportional, which is the Number desired, *viz.* the *Judaical Hour* at the Time given.

P R O B. XXX.

The Judaical Hour being given, to find thereby the Hour of the Day at any Time, according to our Way of reckoning in England.

Elevate the *Pole* according to the *Latitude* of the given Place, and finding the Sun's Place in the *Ecliptick* at the given Time, bring the same to the *Eastern Horizon*, and set the *Index* of the *Horary Circle* at Noon, then turn the Globe *Westward*,

ward, till the Sun's Place coincide with the *Western Horizon*, and the *Index* will point at the Number of equal Hours whereof that Day consisteth, which Number you are to write down, and bring the Sun's Place to the brazen *Meridian*, and setting the *Index* again at Noon, turn the Globe about till the Sun's Place coincide with the *Eastern Horizon*, and the *Index* will point at the Hour of Sun-rising in the given Place. Which done, work by the following Proportion: As 12 is to the given Number of *Judaical Hours*: So is the Length of the Day in equal Hours (formerly found out) to a fourth Proportional, which is the Number desired, *viz.* the Hour of the Day, according to our Way of reckoning in *England*. Only note, that if the fourth Proportional be less than 12, you are to add the same Number of Hours before Noon for that Day; but if it be more than 12, subtract it from 12, and the Remainder will give the Hour of the Day for the Afternoon.

S E C T. IV.

Containing a Description of the
CELESTIAL GLOBE.

IN the vast indefinite Space of the Universe appear the *Celestial Lights*, which are either fixed, as the *Stars*, or errattick as the *Planets*.

The fixed Stars are so called, because they always keep the same invariable Distance from one another as so many *lucid Bodies* or *Suns* in the Concavity of the *Heavens*.

Those Stars that are nearest to us, seem far to exceed others in apparent Magnitude and Brightness: Hence arises the Distribution of Stars, according to their Order and Dignity, into Classes.

The first Class, containing those which are nearest to us, are called *Stars* of the first *Magnitude*, because they appear the greatest and most bright.

Those that are next to them, are Stars of the second *Magnitude*, and so on till
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we come to Stars of the sixth *Magnitude*, which comprehends the smallest Stars that can be discerned with the naked Eye ; for all the other Stars, which are only seen by the Help of Telescopes, are not reckoned among these six Orders.

The *Ancients* divided the fixed Stars, visible in our *Temperate Zone*, into 48 *Constellations*, 12 of which are situate along the *Zodiack*, giving Names to the 12 Signs, or the Portions into which the *Zodiack* is divided.

In the *Northern* half of the *Zodiack* there are *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo* and *Virgo*. In the *Southern*, *Libra*, *Scorpio*, *Sagittarius*, *Capricornus*, *Aquarius* and *Pisces*.

The other Images are considered in respect of their lying either in the *North* or *South* Side of the *Zodiack*. In the *Northern* Region are 21 *Constellations*, viz. the lesser *Bear*, the great *Bear*, the *Dragon*, *Copheus*, *Bootes*, the *Northern Crown*, *Hercules*, the *Harp*, the *Swan*, *Cassiopeia*, *Perseus*, *Andromeda*, the *Triangle*, *Auriga*, *Pegasus*, *Equiculus*, the *Dolphin*, the *Arrow*, the *Eagle*, *Serpentarius* and the *Serpent*. To these were afterwards

added the Constellations of *Antionus*, made out of the unformed ones near *Aquila*, and of *Bernices Hair*, consisting of Stars near the *Lyon's Tail*.

On the *South Side* of the *Zodiack* there are 15 Constellations, which were known to the Ancients, viz. the *Whale*, the *River*, the *Hare*, *Orion*, the *great Dog*, the *lesser Dog*, the *Ship*, the *Hydra*, the *Cup*, the *Crow*, the *Centaur*, the *Wolf*, the *Altar*, the *Southern Crown* and the *Southern Fish*. To these are lately added 12 more Constellations that are invisible to us, being near the *South Pole*; namely, the *Phenix*, the *Crane*, the *Peacock*, the *Indian*, the *Bird of Paradise*, the *Southern Triangle*, the *Fly*, the *Cameleon*, the *Flying Fish*, the *American Goose*, the *Water Serpent*, and the *Sword Fish*.

Without the Compass of the *Constellations*, there are several Stars which cannot be reduced to any of the preceeding *Constellations*, and these are called unformed Stars, out of which *Astronomers* have made new *Constellations*, as *Charles's Heart*, and *Sobiesky's Shield*.

The *Milky Way* comes under this Head of *Constellations*, for the modern *Astro-*

nomers have found it to be a Collection of innumerable little fixed *Stars*, it's a broad Circle, white like Milk, compassing the whole *Heavens*, sometimes in a double, but generally in a single *Path*. The Portion of the *Heavens*, which this Circle passes through, is every Way fill'd with an infinite Multitude of small *Stars*; which, though they are not perceptible to the naked Eye, by reason of their exceeding Smallness, yet by their Light they illustrate that Part of the *Heavens* to which they belong.

There are also two little Clouds situated near the *S. Pole*, somewhat resembling the *Milky-way*, but invisible in *Europe*, and called by the Sailors the *Magellanick Clouds*: Dr. *Halley* assures us, that they are exactly of the Whiteness of the *Milky-way*, and being viewed by a *Telescope*, they present us here and there with little *Nebulae* and small *Stars*. The greater of these two is situated between *Hydrus* and *Dorado*; and the lesser between *Toucan* and *Hydrus*.

By the Help of *Constellations*, the ancient *Astronomers* have digested the *Stars* into Catalogues which they have delivered

down to Posterity: These Catalogues have been much increased and corrected by our modern *Astronomers*, of which the most compleat is to be expected from the Labours of that most excellent Observer Mr. *Flamsteed*, late Royal Professor of *Astronomy* at *Greenwich*. The Number of *Stars* inserted in this Catalogue are 3000, of which there are many that cannot be seen without a *Telescope*.

The fixed *Stars* are Bodies of a fiery Nature, as our *Sun* is; that is, they shine with their own Light, for the native Light that these fiery and flaming Bodies send forth, is stronger and more piercing, and acts upon the nervous Fibres of the *Retina*, with a greater Force than the Light reflected from *Opake* Objects, for all Light is much weakened by Reflection.

It is reasonable to suppose that these fixed *Stars* are *Suns* at great Distances from one another, each of which is surrounded with a Chorus of *Planets* peculiar to it self, which in different Periods and Distances perform their Circulations round their proper *Sun*; every *Sun* doing the same Office to his proper *Planets*

in illustrating, warming and cherishing them, that our *Sun* performs to the System to which we belong.

Besides the apparent diurnal Motion of the *Heavens* from *East* to *West*, the fixed *Stars* seem to have another Motion, whereby they seem to move very slowly from *West* to *East*, or according to the Order of the Signs ; this Motion is so very slow, that it is computed to require 25920 Years for the fixed *Stars* to be carried thereby through the twelve *Signs*: But this *Phenomenon* of the fixed *Stars* arises from the Precession of the *Equinox*, by which they are carried constantly back into the preceding *Signs*, and fall more and more behind the succeeding *Stars*.

The Intersections moving *Westward*, the *Stars* will seem to remove more and more *Eastward* in respect of the *Equinoctial* Points, and therefore the *Longitude* of the *Stars*, which are computed from the first Point of *Aries*, or the Vernal Intersection of the *Equator* and *Ecliptick*, must constantly increase, and all the *Stars* will seem to have a Motion *Eastward*, not that they have really any such Motion, but because the *Equinoctial* Points has a contrary

trary Motion to the *West*, so that the Distances of the *Stars*, or their *Longitude* from the first Point of *Aries*, reckoned *Eastwards*, becomes constantly greater about 50 Seconds each Year. Hence it is that all the *Constellations* have changed their Places; thus, the *Constellation* of *Aries*, that in *Hipparchus's* Time, was near the Vernal *Equinox*, is now removed a whole *Sign* towards the *East*, and is got into the Sign or Portion of the *Ecliptick* called *Taurus*, and so every *Constellation*, has, since the first Observation changed Place with the following: But the Portions of the *Ecliptick* retain still the same Names which they had in the Time of *Hipparchus*.

But as the diurnal *Phenomena* of all the *Celestial* Bodies arise from the simple Motion of the *Earth* about its *Axis*: So this apparent Motion of the *Stars*, forward in the *Ecliptick* ariseth from the Motion of the *Equinoxes*, by which they are carried constantly back into the preceeding *Signs* or *Stars*, and fall more and more behind the succeeding ones; the *Physical* Cause of which was discovered by the incomparable Sir *Isaac Newton*, to arise according

according to the **Laws** of Motion and Gravity from the broad Spheroidical Figure of the *Earth*, and that this broad Spheroidical Figure arises from the Rotation of the *Earth* round its *Axis*.

The fixed Stars are represented on the *Celestial Globe* ; for the understanding of which, observe the following *Definitions*.



DEFINITIONS *and* PROBLEMS for the Celestial Globe.

ALL Circles describ'd on the *Terrestrial Globe*, are also Circles on the *Celestial*. As on the *Terraqueous Globe*, all the *Meridians* described, meet in the *Poles* of the *Equator*, so on the *Celestial*, all the Circles of *Longitude* drawn through the 12 *Signs*, meet in the *Poles* of the *Ecliptick*.

Def. I. Declination of the *Sun* and *Stars* is their Distance from the *Equator*, numbered on a *Meridian*, therefore *Parallels* to the *Equator* are *Parallels* of *Declination*.

Def. II. *Amplitude* is the Distance of the Rising or Setting *Sun* or *Star* from the *East* or *West* Point of the *Horizon*; it is either *Ortive*, when the *Star* rises, or *Occidual*, when it sets.

Def. III. *Right Ascension* of the *Sun* or any *Star*, is that Degree of the *Equinoctial* accounted from the Beginning of *Aries*,

ries, which cometh to the *Meridian* with the *Sun*, or *Star*, or with any Point in the Heavens.

Def. IV. Oblique Ascension is that Degree and Minute of the *Equator* that is rising above the *Horizon* when the *Sun* or *Star* is rising in an *Oblique Sphere*. And *Oblique Descension* is that Degree of the *Equator* which is at the *West Side* of the *Horizon*, when the *Sun* or *Star* is setting in an *Oblique Sphere*.

Def. V. Ascensional Difference is the Difference betwixt the *Right* and *Oblique Ascension*: If the *Latitude* of the Place, and Declination of the *Sun* or *Star* be towards the same *Pole*, viz. both *North*, or both *South*, the *Right Ascension* is the greater, and on the contrary.

Def. V. Longitude of the Sun, Star, or any other Celestial Phenomenon, is an Arch of the *Ecliptick*, contained between the first Point of *Aries*, and the Point whose *Longitude* is required.

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But because the *Ecliptick* is divided into 12 *Signs*, the *Longitude* of a *Star* is therefore (in the most customary Account) an Arch of the *Ecliptick*, comprehended between the Semicircle of *Longitude* passing thro' the beginning of *Aries*, and the Semicircle of *Longitude* passing thro' that Degree of the Sign the *Star* is in.

Def. VI. The *Latitude* of a *Star* is an Arch of a Semicircle of *Longitude*, comprehended between the *Ecliptick* and *Star* : And is either *North* or *South*, according as the *Star* is on the *North* or *South* Side of the *Ecliptick*.

Def. VII. *Azimuth* is the Distance betwixt the *North* Point of the *Horizon*, and that Point where a Vertical Circle passing through the Body of the Sun or *Star*, cuts the *Horizon*, or the Distance betwixt the *Prime Vertical*, and the *Vertical* the Sun or *Star* is upon.

Def. VIII. *Altitude* of the Sun or *Star*, is an Arch of an *Azimuth* Circle comprehended between the *Horizon* and the Parallel of *Altitude* the Sun or *Star* is upon.

Def. IX. The Sun or any Star is said to rise, when they come to the *East Side* of the *Horizon*, and to set when it comes to the *West Side* of the *Horizon*.

The Poets have a threefold Rising of the Stars, *viz. Cosmic, Acronic and Heliac.*

Def. X. A Star is said to rise *Cosmically*, which riseth or sets, then when the Sun riseth. So that a Star that riseth or setteth in the Morning, rises or sets *Cosmically*.

Def. XI. A Star rises *Acronically*, if it rise when the Sun sets, that is in the Evening, when it is in Opposition to the Sun, and is visible at Night.

Def. XII. A Star rises *Heliacy*, when after it has been in Conjunction with the Sun, it comes to be at such a Distance from him, as to be seen in the Morning before Sun-rising.

But the *Heliac* Setting is when the Sun approaches so near a Star that he hides it with his Beams, which keeps the fainter Light of the Star from being perceived.

PROB.

P R O B. I.

To represent the Face or Appearance of the Heavens, or to shew the Situation of the fixed Stars for any Hour of the Night.

Rectify the *Globe* to the *Latitude* of the Place, bring the Sun's Place to the *Meridian*, and the *Index* to Noon, set the *Globe* by the Needle, that its *Cardinal Points* agree with the *Cardinal Points* of the Compass, turn the *Globe* till the *Index* point at the given Hour, and observe what Stars were at or near the *Meridian*, or any other Point of the Compass, for those will appear upon the same Points of the Compass in the Heavens.

Hence it is obvious, that this *Problem* is of good Use to know the *Constellations* and the several remarkable *Stars* in each *Constellation*.

P R O B. II.

To find the Longitude and Latitude of any Star.

For the *Longitude*, screw the *Quadrant* of *Altitude* over that *Pole* of the *Ecliptick* which is nearest to the *Star* whose *Longitude* you seek, then lay the *Quadrant* over the *Center* of the *Star*, look what *Degree* of the *Ecliptick* the *Quadrant* crosseth, which *Degree* numbred from *Aries* is the *Star's Longitude*.

For the *Latitude*, the *Quadrant* fitted as before, and laid over the *Center* of the *Star*, then the *Degrees* of the *Quadrant* comprehended between the *Ecliptick* and *Star* is its *Latitude*.

P R O B. III.

To find the Right Ascension and Declination of the Sun or Star.

For the *Right Ascension*, the *Globe* being rectified, bring the *Sun* or *Star* to the *Meridian*, and the *Degrees* of the *Equator* contained between the *Beginning* of *Aries* and the *Meridian* is the *Right Ascension* : The *Sun* or *Star* being at the *Meridian*,

Meridian, the Degrees of the same *Meridian* contain'd between the *Equator* and the *Star* is its *Declination*.

P R O B. IV.

To find the Distance of two Stars.

Apply the *Quadrant* of *Altitude* to the two *Stars*, the Degrees of the *Quadrant* intercepted between them, is their *Distance*; if the *Quadrant* be too short, you may take their *Distance* with a Pair of *Compasses*, which applyed to any graduated great *Circle*, gives their *Distance* in *Degrees*.

P R O B. V.

To know what Day in the Year any Star shall be upon the Meridian at 12 a Clock at Night.

Bring the *Star* to the *Meridian*, and mark what Degree of the *Ecliptick* is at the *North Meridian* under the *Horizon*, and on the *Horizon* find what Day of the Year standeth against it, for that Day of the Year will that *Star* be upon the South
Part

Part of the *Meridian* at 12 a Clock at Night.

P R O B. VI.

The Sun's Place and Altitude of a known Star being given, to find thereby the Hour of the Night.

The Globe being rectified, bring the Sun's Place to the brazen *Meridian*, and set the *Index* to 12, then move the *Globe* and *Quadrant of Altitude* together, till the Star meet with its *Altitude* upon the *Quadrant*, and the *Index* will point out the Hour of the Night.

P R O B. VII.

The Month and Day being given, as also the Place of the Moon in the Ecliptick, and her Latitude; to find the Hour of her rising and setting, as also the Time of her coming to the Meridian of the given Place.

The Moon's Place in the *Zodiack* may be found at any Time by an *Ephemeris*. For the Solution of this Problem, elevate the Pole to the *Latitude* of the Place, find the

the Sun's Place in the *Ecliptick*, and mark it with Chalk, as also the Moon's Place at the same Time : Bring the Sun's Place to the brazen *Meridian*, and set the *Index* of the *Horary-Circle* at Noon, and turn the Globe till the Sun's Place successively coincide with the *Eastern* and *Western* Sides of the *Horizon*, as also the brazen *Meridian*, and the *Index* will point at those various Times, the particular Hour of her *rising*, *setting* and *southing*.

PROB. VIII.

Any Star being given, to find its Oblique Ascension or Descension, as also its Eastern and Western Amplitude.

Rectify the Globe to the *Latitude* of the Place, and bring the Star to the *Eastern* Part of the *Horizon*, and mark the Degree of the *Equator* that ascends with it, for the Arch of the *Equator* intercepted between the Beginning of *Aries* and the Point thus marked is the *Oblique Ascension* of the Star.

And the Arch of the *Horizon* intercepted between the *East* and the Place of the Star, is the *Eastern Amplitude* of the Star :
And

And if you bring the Star to the *Western* Side of the *Horizon*, the Degree of the *Equator* then descending will be the *Oblique Descension*; and the Arch of the *Horizon* intercepted between the *West* Point of the *Horizon* and the Star will be its *Western Amplitude*.

P R O B. IX.

To know by the Globe at what Hour any known Star cometh upon the Meridian for any Day in the Year, as also the Time of its rising and setting.

Rectify the Globe to the *Latitude* of the Place, bring the Sun's Place (for the given Day) to the brazen *Meridian*, and set the *Index* to Noon, then turn the Globe till the Star come to the *Meridian*, as also the *Eastern* and *Western* Side of the *Horizon*, and the *Index* will point at those various Times, the Hours of the Star's *rising*, *setting* and *southing*.

S E C T.

S E C T. V.

Of the SOLAR SYSTEM.

BESIDES the fixed *Stars* described in the foregoing *Section*, there are other shining Bodies to be observed, which perform their Revolutions round the *Sun* in very different Periods of Time, and therefore they must have constantly variable Positions, and be always changing their Distances from one another, as well as from the fix'd *Stars* : These *Globes* or *Stars* are called *Planets* or *Wanderers*, and are divided into *Primary* and *Secondary*.

The *Primary Planets* are in Number six, and describe their *Orbits* about the *Sun* from *West* to *East*, in the following Order : viz.

☿ *Mercury* next the *Sun*, in 87 Days,

♀ *Venus* in 224 Days 17 Hours.

⊕ The *Earth*, in 365 Days, 5 Hours, and 49 Minutes.

M

♂ *Mars*

3 *Mars*, in 687 Days.

4 *Jupiter*, in 4332 Days, 12 Hours, that is almost 12 Years.

5 *Saturn*, the farthest distant of all the Planets, in 10759 Days, that is near 30 Years.

Their Distances from the *Sun* are nearly in this following Proportion: That is, supposing the Distance of the *Earth* from the *Sun* to be divided into ten equal Parts, the Distance of *Mercury* will be about four of those Parts; that of *Venus* seven; of *Mars* fifteen; of *Jupiter* fifty two; and that of *Saturn* ninety five.

Three of the *Primary Planets*, viz. the *Earth*, *Jupiter* and *Saturn* have *Satellites*, or other Planets revolving about them, hence called *Secondary Planets*. The *Earth* has one, viz. the *Moon*, completing its Revolution in 27 Days, 7 Hours, and distant about 60 Semidiameters of the *Earth* from it.

Jupiter has 4 *Satellites* who attend him, that which is next to him, is no further removed than $2\frac{1}{2}$ of his Diameter, and turns round him in one Day; $18\frac{1}{2}$ Hours. The second revolves at the Distance of $4\frac{1}{2}$ Diameters, in 3 Days, 13 Hours. The

third at the Distance of 7 Diameters, revolves about him in 7 Days 4 Hours. The fourth at the Distance of 12 Diameters of *Jupiter*, compleats his Period in 16 Days $16\frac{1}{2}$ Hours.

Saturn has five Attendants or *Satellites*, the nearest compleats its Revolution in $1\frac{2}{3}$ Days, and its distance from *Saturn's* Center is $4\frac{1}{3}$ of his Semidiameter. The second revolves about *Saturn* in 2 Days 17 Hours, at the Distance of $5\frac{1}{3}$ Semidiameter of *Saturn*. The third in 4 Days 12 Hours, who finishes his Revolution at the Distance of 8 Semidiameters. The fourth compleats its Period in 16 Days, and is distant from *Saturn* 18 of his Semidiameters. The fifth and outermost that has been discovered, revolves about *Saturn* in $79\frac{1}{3}$ Days, at the Distance of 54 Semidiameters from the Center of *Saturn*.

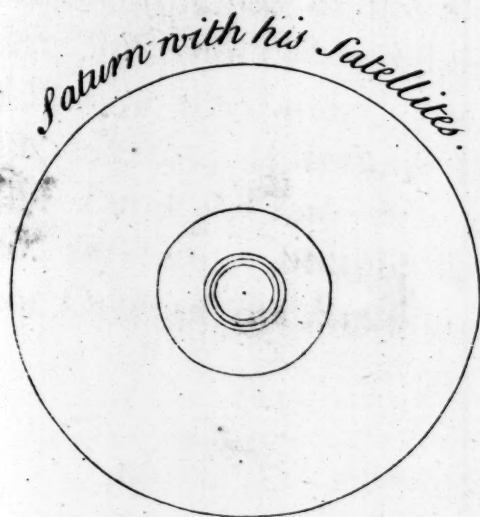
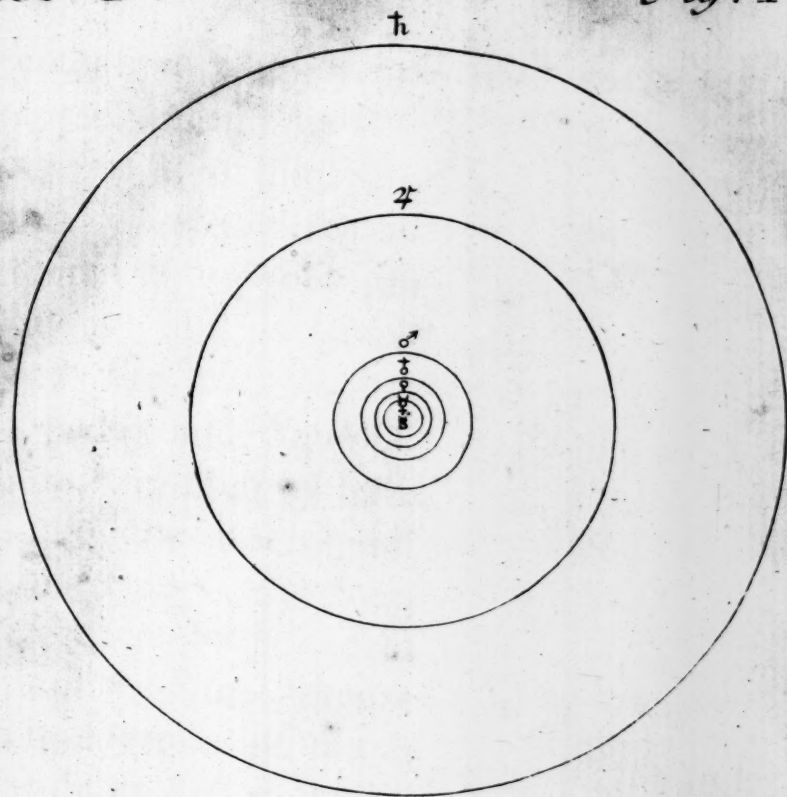
Besides these Attendants, *Saturn* has an Ornament peculiar to himself, for he is dignified with a Ring, which surrounds his Middle, and does no where touch his Body, but is like an Orbicular Arch, built round him, it is *Opaque*, like a *Planet*, and from the various Positions of it, in respect of the *Sun*, illuminating it, and the

Situation of the Observer, the various *Phases* of the Ring of *Saturn* arise. The Diameter of the Ring is to that of *Saturn* as 9 to 4, and the Breadth of the Space between the Ring and the Body of *Saturn* is equal to the Breadth of the Ring itself.

There are another Sort of Bodies which revolve about our Sun, *viz.* the *Comets*, which may be look'd upon as *Planets*.

The Figures of *Comets* are very different, for some throw Beams every Way round them, and they are called *Hairy Comets*; others again have a fiery Tail, opposite to the Region in which the Sun is seen, and they are called *Bearded*, or *Comets with Tails*. Their Magnitudes have also been observed to be very different, many of them without their Hair (as it is call'd) appearing no bigger than Stars of the first Magnitude: But some Authors have given us an Account of others which were much greater.

Several *Philosophers* and *Astronomers* have maintained that the Motion of the *Comets* is Rectilinear; but that which answers best to their Appearances, is a Motion in a *Parabolic* or *Elliptical Orbit*,



bit, and when they come to the inferior Parts of their Orbits, and descend towards the Sun, or just ascending from him, then only they become visible, afterwards ascending higher in their *Orbits*, they run into far distant Regions, and withdraw themselves from our Sight.

All the *Planets Primary* and *Secondary* are *Opaque Bodies*, *i. e.* such as have no Light of their own, but receive and reflect back again all their Light from the Sun, and therefore are accounted as so many Dependants of the Sun, whence the Sun with those its Dependants makes up what is called the *Solar System*, represented in Fig. 4. Plate 2.

The *Planets* in respect of the *Earth* are divided into *superiour* and *inferiour*. The *superiour Planets* are *Saturn*, *Jupiter* and *Mars*, because they surround the *Orbit* of the *Earth*: *Venus* and *Mercury* are called *inferiour*, because contained within the Orbit of the *Earth*.

S E C T. VI.

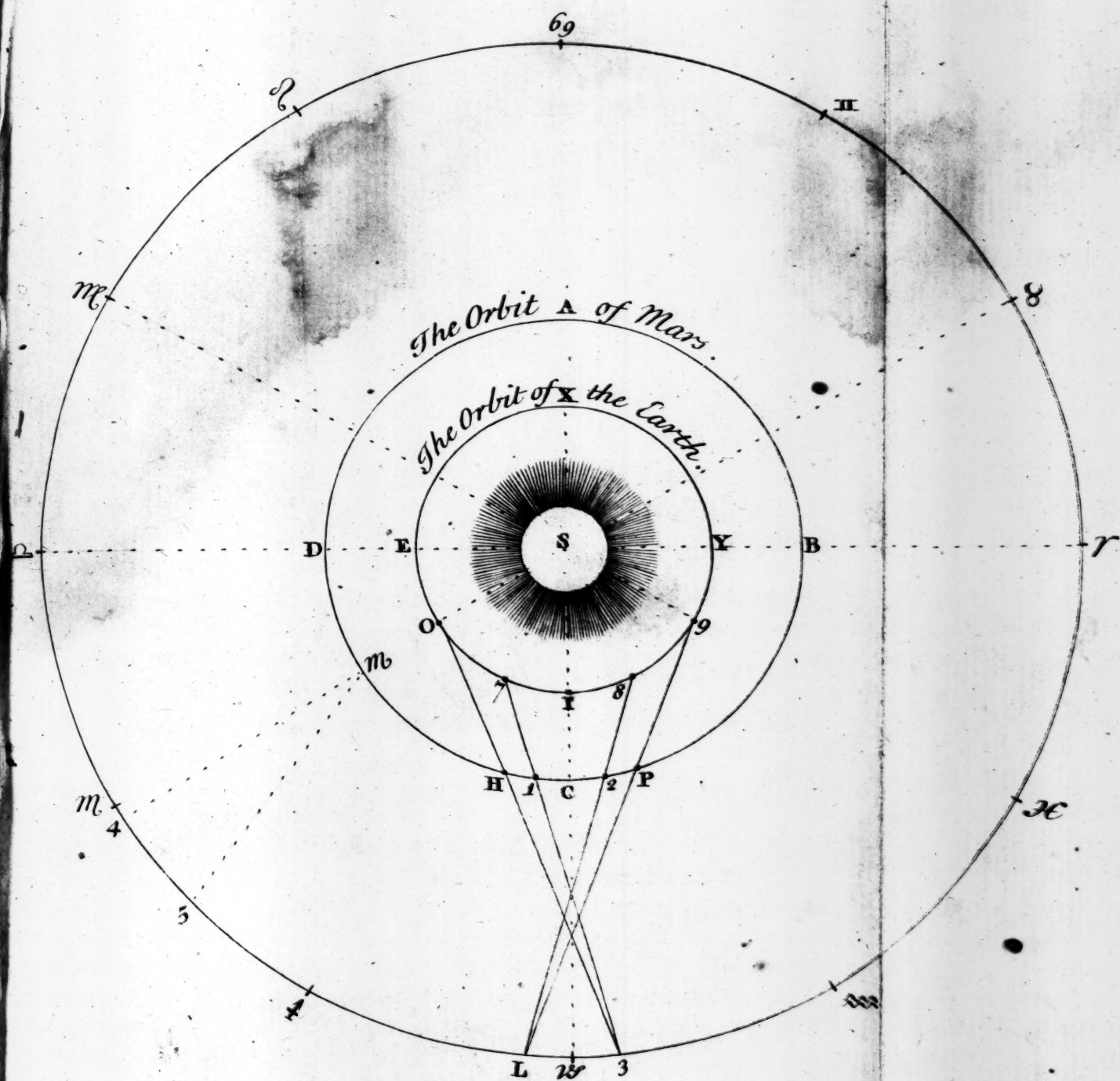
To describe the Phenomena arising from the Motion of the Earth, and Primary Planets.

THE Motions of the *Planets*, both *superiour* and *inferiour*, are regular, according to the Order of the *Signs* of the *Zodiack*, performing their Motions in *Elliptical Orbits* about the Sun, but this Motion appears to the Inhabitants of our Earth very irregular, for they appear at sometimes to move very swift, according to the Order of the *Signs*, and at other times they seem to move more slow, but still direct : Again, they appear sometimes to have no Motion, continuing to rise and set for several Days with the same fix'd Stars, and then they are said to be *Stationary* ; at other times they appear to move contrary to the Order of Signs, and then they are said to be *Retrograde* : all which irregular Motions of the *Planets*, are natural Consequences of the Motion of the Earth

Earth round the Sun ; to explain which, let the *Zodiack* be represented by $\gamma, \delta, \epsilon, \zeta, \eta, \theta, \iota, \kappa, \lambda, \mu, \nu, \xi, \omicron, \pi, \rho, \sigma, \tau, \upsilon, \phi, \chi, \psi, \omega$, &c. (Fig. 5. Plate 3 .) S the *Sun*, and A B C D the *Orbit* of *Mars*, one of the *superiour Planets*, and T represents the *Earth* in its *Orbit* T E X Y : The *Earth* and Planet moving from *West* to *East*, according to the Order of the Signs.

When the *Earth* is at Y, and the Planet at D, it will appear in *Conjunction* with the *Sun* by the Line that points out their Place among the fixed Stars, and in this Case the *Sun* and Planet will appear to rise and set with the fixed Stars in $\approx$, and the Planet will then be in its *Apogee*, or greatest Distance from the *Earth*, the *Earth* moving in its *Orbit* from Y to X, while the Planet, which does not move so swift as the *Earth*, has described the *Arch* D m, the true Motion of the Planet, since its *Conjunction* with the *Sun* is the *Arch* of the *Ecliptick* ≈ 4 , but it will appear to an Observer on the *Earth*, to have run over the *Arch* ≈ 5 , according to the Order of the Signs, which is greater than ≈ 4 , wherefore it appears direct and swift in its Motion, the *Sun* then appears from the *Earth* among the fixed Stars in
the

the Sign $^{\text{vs}}$, which is farther advanced in the *Ecliptick* than the Planet in $^{\text{m}}$, therefore the Planet appears to rise in the Morning before the Sun. The Earth and Planet advancing in their Orbits, when the Earth shall come to T, if the Planet be at C in its Orbit, it will appear opposite to the Sun, and in its *Perigee*, or nearest Distance from the Earth, for when the Planet is in C, its nearer to the Earth in T, by the Diameter of its annual Orbit, than when it appeared from the Earth to be in Conjunction with the Sun. But when the Earth is arrived at O, if *Mars* be in H, it will become *Stationary* in order to its being *Retrograde*, for the *superiour Planets* appear *Retrograde* every time the Earth passes between them and the Sun: But since the Planet when it appeared from the Earth at X, appeared to move forward according to the Order of the Signs, and afterwards to return backwards, between the *progressive* Motion, and *regressive*, there will be a Point where it will appear to stand and continue in the same Situation in the *Heavens*. Now it seems to keep the same Station in the *Heavens*, when a Line that joyns the Center of the Earth and Planet, is constantly





stantly directed to the same Point among
the fixed Stars.

Thus the Earth being at the Point O, and the Planet in H, it will appear among the fixed Stars at 3, then if the Earth move from O to 7, and in the same Time the Planet move from H to I, it will appear from the Earth with the same fixed Stars at 3, which it appeared with in H, and all the Time the Earth and Planet were in describing the Arches O 7, and H I in their respective Orbits, the Planet continued to rise and set with the same fixed Stars, because the Lines O H and 7 I, joining the Earth and Planet Centers, is all that Time directed to the same Point in the *Heavens*, which explains the Station of *Mars*, preceeding his *Retrogradation*.

After which, if we suppose the Earth to have moved from 7 to 8, and the Planet from 1 to 2, it shall be seen among the fixed Stars at L, which is more *West* than the Point 3, under which it was seen before, which shews its *Arch of Retrogradation*. Lastly, the Earth having moved from 8 to 9, and at the same Time the Planet from 2 to P, it will appear all that

N
Time

Time with the same fixed Stars in *L*, which is the second Station, or that which succeeds its *Retrogradation*, whereas in the mean while, if viewed from the Sun, it seemed to move all this Time, as before, in *Consequentia*, or according to the *Order* of the *Signs*.

These are the apparent *Phenomena* of *Mars* seen from the Earth, and the like *Phenomena* will happen to *Jupiter* and *Saturn*, excepting that *Saturn's Retrogradations* are more frequent than *Jupiter's*, and *Jupiter's* more frequent than that of *Mars*, because the Earth oftner overtakes *Saturn* than *Jupiter*, and *Jupiter* oftner than *Mars*, and passes between them and the Sun.

The *Arch* of *Retrogradation* appears the greater in Proportion, as the Planet is near the Earth; wherefore that of *Mars* is greater than that of *Jupiter*, and the *Arch* of *Retrogradation* of *Jupiter* greater than that of *Saturn*.

Since the *inferiour Planets*, *Venus* and *Mercury* move round the Sun at a less Distance than the Earth, it's evident that they will always seem to attend the Sun, sometimes to go to the *West* of him, and some-
 4 times

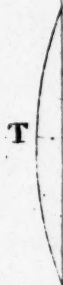
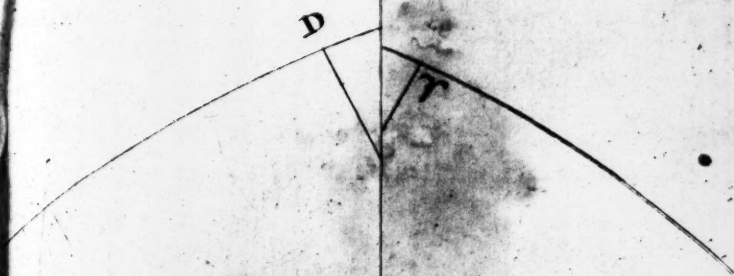
times to the *East*; this *Digression* to the *East* or *West* is called their *Elongation*, and is measured by an *Arch* of a great *Circle* intercepted between the Planet and the Sun, when a Line, which joins their *Centers*, with the Eye of the Observer on our Earth, is a *Tangent* to their *Orbits*.

The *Elongation* of *Venus* never exceeds 48° , or that of *Mercury* 29° .

When they are at their greatest *Elongation* from the Sun, they will return to the Sun again, and pass as far on the other Side of him, as if their Motions were *Oscillatory*. By which it's plain, that they will in the Time of their *Revolution* about the Sun, appear twice in *Conjunction* with him; the one *superiour*, the other *inferiour*. When the Planet is betwixt the Earth and the Sun, 'tis then in its *inferiour Conjunction*, or nearest Distance from the Earth, at which Time, if the Planet be in the *Ecliptick*, that is, in one of its *Nodes*, it will appear as a Spot on the Face of the Sun, and *Retrograde*. When the Sun is directly between the Earth and Planet, is then in its *superiour Conjunction*, appearing from the Earth di-

rect and swift in its Motion, as also in its greatest Distance from the Earth.

To explain the irregular *Phenomena*, of *Mercury*, let us suppose γ , δ , π , (Fig. 6. Plate 4. the 4th Part of the *annual Orbit*, which the Sun appears to describe in three Months, in which Time *Mercury* describes its Orbit, 1, 2, 3, 4 5, about the Sun. If the Earth, in its *Orbit* is in A, and *Mercury* in 1, it will appear to us in the Sign γ . then if the Earth be advanced to X, and *Mercury* to 2, we shall see it in the Sign δ at the Point B, and while its Motion is from γ to δ , or according to the Order of the Signs, we call it *Direct* ; but when the Earth is in E, and *Mercury* in 3, it appears to us still with the same Sign at the Point B, though it has really moved in its *Orbit* from 2 to 3, and because it rises and sets for some Days with the same fixed Stars, 'tis said to be *Stationary*, and this Station is that which preceeds its *Retrogradation*. When the Earth is advanced to D, and *Mercury* to 4, the Observer will see it from the Earth in the Sign δ at the Point C, and it appears to have gone back, contrary to the Order of the Signs ; therefore it's said to be *Retrograde*:



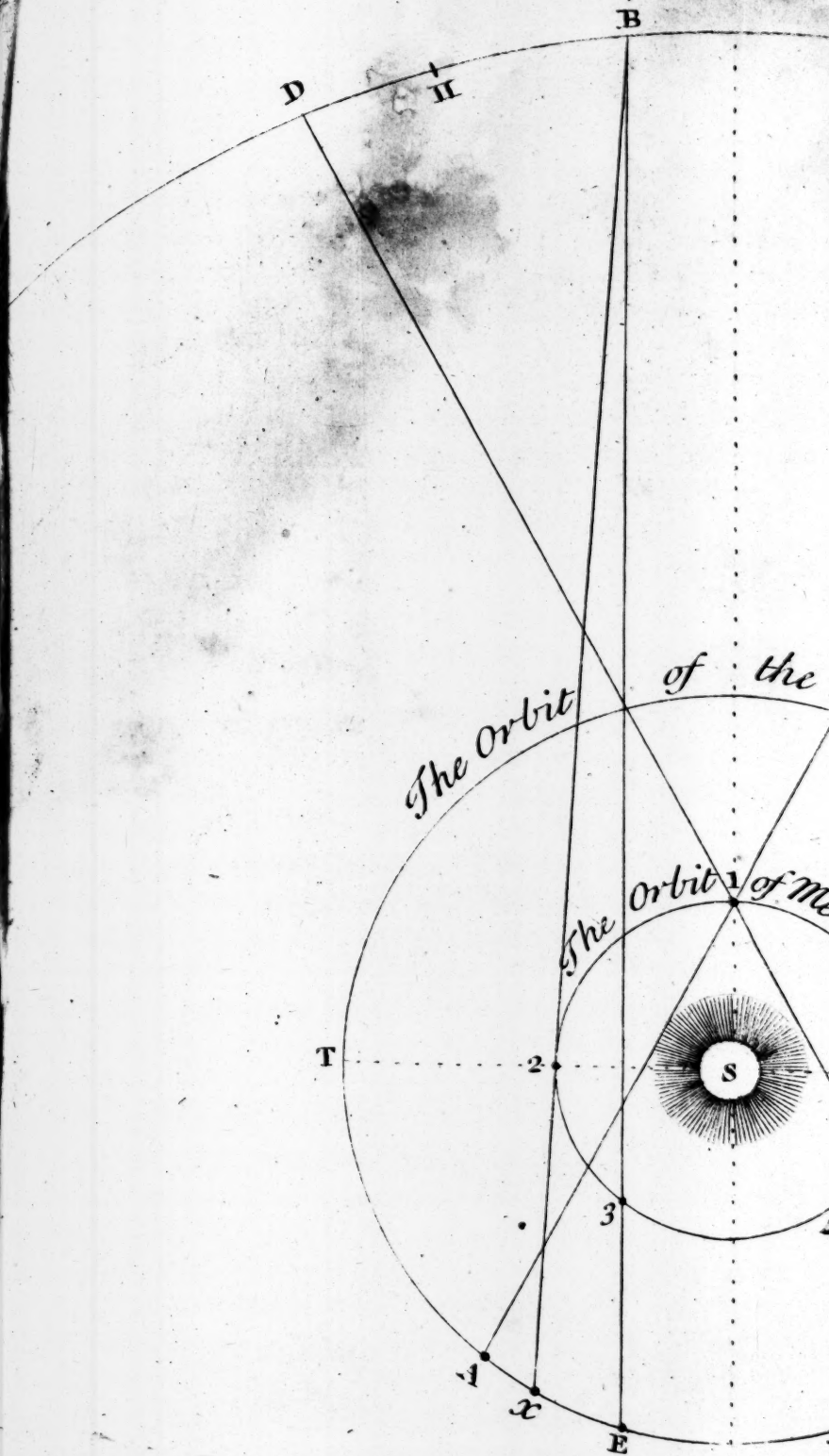
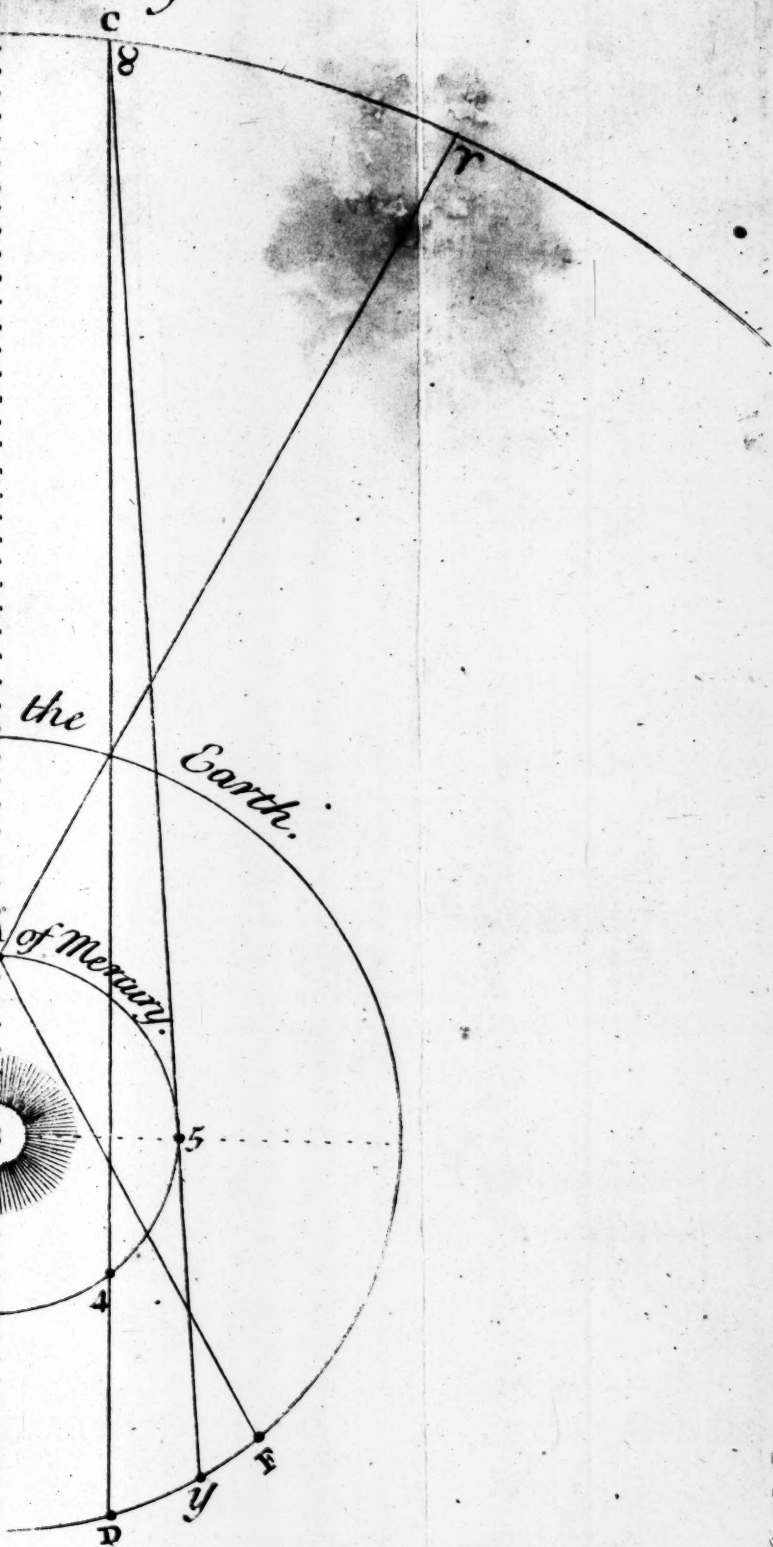


Fig. 6.



etrograde: And the *Arch* BC, is the *Arch* of its *Retrogradation*, when it is advanced to 5, and the Earth at Y, it will appear in $\odot$ at C, which is its second Station. Lastly, when the Earth is come to F, and *Mercury* to I, it will appear among the fixed Stars at the Point D, and direct in its Motion.

The apparent Irregularities of the particular Motion of *Venus*, may be explained after the same manner: Its *Stations* and *Retrogradations* are not so frequent, since it sometimes appears direct for a Year; because *Mercury* finisheth its Course in a shorter Time, and consequently overtakes the Earth oftner than *Venus*. And since *Mercury's* Orbit is less than that of *Venus*, its greatest *Elongation* must be also less, and it must be a nearer and more constant Attendant of the Sun.

*Of the PHASES and LATITUDE
of the PRIMARY PLANETS.*

SINCE all the *Planets* are *Opaque, Spherical Bodies*, reflecting the Rays of Light that fall upon them every Way, 'tis evident that that Half of each Planet which is exposed or turned to the Sun, is enlightned by it, while the other Half, which is turned from the Sun is in Darkness.

And since that Half only which is towards the Earth is seen by the Observer, it is manifest (by Fig. 7. Plate 5.) that when *Venus* is in A, that is most *Retrograde*, and nearest to the Earth at T, it is not visible at all, having its dark Face turned towards us, and if *Venus* were at the same Time in the *Plane* of the *Ecliptick*, that is in one of its Nodes, it would appear like a Spot in the Sun.

When *Venus* is in B, then some Part of the enlightened Half is turned towards the Earth, and because *Venus* is of a *spherical Figure*,

Figure, and appears like a *Plane*, its enlightened Part will appear horned.

When *Venus* is at C, half the enlightened Part will be seen by an Observer at T, at D it's said to be *Gibbous* above half the enlightened Part being visible, at E, where it's farthest off, and most direct in its Motion, it appears full, all the enlightened *Hemisphere* being turned towards us at T.

Venus will have the same Variety of *Phases* in its Passage through F, G and H; that is, it will be *Gibbous* at F, *half full* at G, and *horned* at H.

These Appearances of *Venus*, tho' they are not to be discerned by a naked Eye, yet they are distinctly and plainly to be perceived with a *Telescope*.

The like *Phenomena* will appear in *Mercury*, regard being had to its *Orbit* and *Revolution*.

The superiour *Planets*, *Saturn* and *Jupiter* are also illuminated by the Sun, but that Half of each *Planet* which is turned towards the Sun; that is, the illuminated Half is likewise turned towards the Earth, because the Earth seen from *Jupiter* or *Saturn* is always to be observed near the
Sun's

Sun's Body, that is, near the Center of their Motions ; therefore the *Inhabitants* of our *Globe* do always behold these Planets shining in full *Orbs*, but the *Orbit* of *Mars* lying very near the Earth, its Face, which is towards the Sun will not always be turned towards the Earth. Thus, let T, (Fig. 7. Plate 5.) represent the Earth in its *Orbit*, it's evident that *Mars* being in M or K, that is in Conjunction or Opposition to the Sun, has the same Face turned towards the Earth as it has towards the Sun, and consequently appears full ; but if *Mars* be in L or I, then some Part of the *illuminated Face* will be turned from the Earth, and therefore *Mars* will appear *Gibbous*, the Light being a little deficient towards those Parts that are turned from the Sun.

The Time between two *Conjunctions* of the Sun and *Saturn* seen from the Earth, according to their Mean Motions may be found thus,

The Earth, according to its Mean Motion, describes an *Arch* of the *Ecliptick* of 59 Minutes 8 Seconds, and *Saturn* moves 2 Minutes in a Day, therefore the Earth
will

will appear from the Sun to recede from *Saturn* 57 Minutes 8 Seconds.

Then say, as 57 Minutes 8 Seconds is to 360 Degrees, so is one Day to a 4th Quantity, which is 378 Days, or one Year and 13 Days, the Time between two Conjunctions or Oppositions of the Sun and *Saturn* according to their Mean Motions.

By the same Method we find that the Time between two *Conjunctions* or *Oppositions* of the Sun and *Jupiter*, is one Year and 33 Days, and that of *Mars* 2 Years and 50 Days.

The *Ecliptick* being that Path which the Earth describes about the Sun, or the apparent annual Motion of the Sun about the Earth, is taken by *Astronomers* as the *Standard* to which the *Planes* of the other *Orbits* are judged to incline: And the Right Line, which passes thro' the Sun, and is the common *Section* of the *Plane* of the *Orbit* with the *Plane* of the *Ecliptick*, is call'd the Line of the *Nodes*, of that *Planet*, and the Points where the *Orbit* of the *Planet* cuts the *Ecliptick*, are called the *Nodes*. Thus (Fig. 8. Plate 5.) let **T A B C** be the Plane of the Earth's *Orbit*,

O
infinitely

infinitely produc'd, N P n the *Orbit*, of any Planet intersecting the Plane of the former *Orbit*, or *Ecliptick*, in N and n, which are the *Nodes* of that Planet.

So as that if one Half, N P n, of that *Orbit*, be suppos'd above the Plane of the Scheme, and the other n p N, below it, which makes it look like an *Ellipse*, the right Line N n, joyning the *Nodes*, being the common Section of the Plane of the *Orbit* of the Planet, with the Plane of the *Ecliptick*, is the Line of the *Nodes*.

The Planes of the *Orbits* of the Planets are inclined to the Plane of the *Ecliptick* in the following Manner, *viz.* the *Orbit* of *Saturn* makes an Angle $2\frac{1}{2}$ Degrees, *Jupiter* $1\frac{1}{2}$ °, *Mars* almost 2°, *Venus* about $3\frac{1}{2}$, *Mercury* almost 7°. And these Inclinations are call'd the *Heliocentrick Latitudes* of the Planets, and is represented in Fig. 8. by the Angle P O L, supposing the Line P L to be perpendicular to the Plane of the *Ecliptick*. And this *Heliocentrick Latitude* will be continually increasing till it come to the Point X, which is call'd the Limit or utmost Extent of it, and then it will decrease till it come to nothing in n, after which it will increase till it come to

to p : And lastly will be decreasing till the Planet come to be in N.

The *Geocentrick Latitude* of the Planets, or their Distance from the *Ecliptick* as they are seen from the Earth, depends much upon the *Position* and Distance of the Earth: for, where the *Heliocentrick Latitude* continues the same, yet according to the various Positions, the Earth may have the *visible Latitude* of a Planet seen from thence will be various; for, let T t B Fig. 9. be the *Orbit* of the Earth, and σ N n the *Orbit* of the Planet *Mars*. Suppose *Mars* in σ , and the Earth in T, so that σ may be observed in Opposition to the Sun, and from *Mars* let fall, on the Plane of the *Ecliptick*, the Perpendicular σ E, this Line will subtend the Angle σ T E, the *visible Latitude*. But if the Earth was in t, so that *Mars* was seen in *Conjunction* with the Sun, its *visible Latitude* would be the *Arch* which measures the Angle σ t E, which is much less than the Angle σ T E, and nearly in the Proportion as the Distance T σ , is to the Distance t σ .

Geocentrick Latitude) is measured by the Angle $\angle T E$, the right Line $\angle E$ being made perpendicular to the Plane of the *Ecliptick*. If *Venus* be suppos'd to continue in $\angle$, and the Earth to be at t , in which Supposition *Venus* is direct, and furthest off the Earth; the *Geocentrick Latitude* of *Venus* will be the Angle $\angle t E$, less than $\angle T E$, almost in the *Ratio* of $T \angle$ to $t \angle$, tho' the *Heliocentrick Latitude* of *Venus* be in both Cases the same.

And what has been now said of *Venus*, is also true in *Mercury*; consequently all other Circumstances being alike, the *Latitude* of the *inferiour Planets* is greater when they are *Retrograde* and nearest the Earth; less, when direct and farthest off.



S E C T. VII.

*Of the Phases and Motions of
the Secondary Planets.*

THE *Primary Planets* have the Sun which they regard as a *Center* for the *Regulator* of their Motions, but the *Secondary Planets* turn round their respective *Primary Ones* as *Centers*: So the Moon, the Earth's *Satellite*, is kept in our Neighbourhood, by a natural Propension or Gravity towards its *Center*, by the Means of which, it is constantly turned out of a rectilinear Course, and is obliged to perform its Revolution round the Earth in 27 Days 7 $\frac{1}{4}$ Hours: And moves from *West* to *East* the same Way as the Earth does, from A through B C, &c. Fig. 11. Plate 6.

The Plane of the Moon's *Orbit* does not coincide with the Plane of the *Ecliptick*, but is inclined to it by an *Angle* of about 5 Degrees, and the common Intersection of these Planes is the right Line $\Omega\vartheta$, the
Points

Points $\Omega\vartheta$ where the *Orbit* of the Moon intersects the Plane of the *Ecliptick*, are called the *Nodes of the Moon*. So that the *Orbit* of the Moon is to be conceived as Half above and Half below the Plane of the *Ecliptick*, the former $\Omega A \vartheta$ to the *North*, and the latter $\Omega K \vartheta$ towards the *South*, which makes it appear in the Figure of an *Ellipse*.

The Line of the *Nodes* does not always keep the same Position, but is moved backwards, *viz.* Ω , through G F, &c. and ϑ thro' C B, &c. contrary to the Order of the *Signs* compleating a Revolution in about 19 Years, from whence it's certain that the Moon can never be found in the *Ecliptick* above twice in its monthly Course; namely, when it is in the Node Ω or ϑ , all the rest of the Time it is either on the *North* or *South* Side of it, and the *Latitude* of the Moon (that is, her Distance from the *Ecliptick*) is measured by the *Angle* in which the right Line connecting the *Center* of the Moon and Eye, is inclined to the Plane of the *Ecliptick*, agreeable to what was said concerning the *primary Planets*.

Besides,

Besides, the Moon, like the other *primary Planets*, being an opaque, rough, *Spherical Body*, reflecting back the Sun's Rays falling upon it, that Half of the Moon's Body, which is turned towards the Sun, is illuminated by him, whilst the other Half, which is opposite, is involved in Darkness; but the Face of the Moon, that can be seen by the *Inhabitants* of the Earth, is that which is turned toward the Earth, and therefore according to the various Position of the Moon in respect of the Sun and Earth, we do observe different Illuminations; one time a larger, at another time a lesser Portion of the illuminated Surface is to be seen; sometimes there is no Part of it visible, and sometimes we see the whole, and see the Moon with her full Face: For the better understanding of this Matter, we will explain it by Fig. 13. Plate 6. In which let S represent the Sun, T the Earth, R T I a Portion of the Earth's Orbit, which it describes in its *annual Course* round the Sun.

Let A B C D E F G H be the *Orbit* of the Moon, in which she turns round the Earth in the Space of a Month from the *West* towards the *East*.

When

When the Moon is in A, the Point of its *Orbit* opposite to the Sun, all the illuminated Face of the Moon will be turned towards the Earth, and be visible by its Inhabitants, and then the Moon is said to be full, and shines all Night long; and in respect of the Sun, she is said to be in Opposition; for the Sun and Moon are seen in opposite Parts of the Heavens, the one rising in the *East* when the other sets in the *West*. When the Moon comes to B, the whole illuminated *Disk* M P N is not turned towards the Earth, there being a Part of it M P, not to be seen by us, and then the visible Illumination will be different from a *Circle*, and the Moon will appear *Gibbous*, such as is marked in B Fig. 12. Plate 6.

The Moon arriving at C, where the *Angle* C T S is nearly right; there, only one Half of the illuminated Part, is turned towards the Earth at T, and to be seen from thence, and then we observe a Half Moon as in C, and then she is said to be *Bisected* or *Dichotomised*, that is, cut in Halves. In this Position the Sun and Moon are removed one fourth Part of a *Circle*

P from

from each other, and the Moon is said to be in her *Quadrature*.

The Moon going forward to D, the Face of the Moon turned towards the Earth, is for the most Part in Darknes, the Portion M P, of the illuminated Face M P N, being turned from the Earth, the *Circle* bounding Light and Darknes with the *Circle* of *Vision*, doth form two small *Angles*, and will look like what we call *Horns*, and the *Phases* seen from the Earth will appear as in D, Fig. 12. Plate 6.

When the Moon is come to the Point E, or in *Conjunction* with the Sun, all the enlightened Half will be turned from the Earth, and consequently the Moon will be entirely dark, and become a New Moon, soon after it will appear at F, and shew its *Horns*, which are always turned from the Sun. Afterwards, being upon the Increase, it will appear a Half Moon at G, then *Gibbous* at H, and returns again to A, where it appears again to be full, to the Earth at T.

Tho' the Time of the Moon's Revolution about the Earth be but 27 Days $7\frac{1}{4}$ Hours, which is called a *periodical Month*: Yet, by a Month, or entire *Lunation*,

nation, is commonly understood all that Space of Time that is spent from one New Moon to the next following, and is called a *Synodical Month*, and is greater than a *Periodical Month*, because during the whole *periodic Month*, the *Earth* it self, together with the *Moon* its Attendant, is advanced almost a whole *Sign* towards the *East*, so that the Point of the *Orbit*, which in the former Position was placed in a right Line joining the *Centers* of the *Earth* and *Sun*, is now more *Westerly*, and therefore when the *Moon* is again at that Point, it will not be seen in *Conjunction* with the *Sun*, for let AB (Fig. 13. Plate 6.) represent a Portion of the *Orbit* of the *Earth*, and when the *Earth* is at T, suppose the *Moon* in L, and proceeds in describing its *Orbit* L A C D; the *Earth* in that Time is carried from T to t, 27 Degrees forward in its *Orbit*, and the *Orbit* of the *Moon* is in the Position l a c d, and the Point of the *Orbit* L, is now in the Line t l, parallel to the former T L.

Hence it is plain, that when the *Moon* is come to l, having describ'd its whole *Orbit*; that it is not arrived at a *Con-*

junction with the *Sun*, but must still go further, and move through the *Arch* *l M*, before it can get between the *Earth* and the *Sun*, which is an *Angle* of 27 Degrees, and because the *Earth* is still going forward, therefore it's required that the *Moon* describe an *Arch* greater than *l M*, to be in *Conjunction* with the *Sun*; so that a *Synodical Month* consists of 29 Days 12 $\frac{1}{4}$ Hours, that is, the Time the *Moon* takes to finish an intire *Lunation*, and all the various Changes of its Appearances.

Observations have discovered to us, that the *Moon* is constantly changing her Distance from the *Earth*, which ariseth from the *Elliptick Orbit*, which she describes about the *Earth*, as (A B C D, Fig. 14. Plate 6.) having the *Earth* in one of its *Focus's* at T, it's plain, that when the *Moon* is in C, it is nearest the *Earth*, and is then said to be in *Perigee*; and in *Apo-gee* when in A, that is, when furthest removed from the *Earth*.

The same Face of the *Moon* is always turned towards us, which ariseth from her Motion wherewith she turns round her
Axis,

Axis, in the same Time that she moves round the *Earth* in her *Orbit*.

When there are no Clouds in our Air, the *Moon* constantly appears with the same *Lustre*; from which it is apparent that there are no Clouds, nor Vapours in the *Moon*, from whence Rain may be generated, for such would sometimes cover some of its *Regions* from our Sight, which we never observe them to do.

It's also probable, that the *Moon* has no *Atmosphere* to surround it; for the *Planets* and *Stars* which are sometimes seen very near its Limb, have not their Light *refracted*, as it is when it passes through our *Atmosphere*.

The other *Secondary Planets* (*viz.* *Saturn's* five *Satellites*, and *Jupiter's* four) like our *Moon*, do always accompany their *Primary Planets* in their Circuits round the *Sun*, and in the mean Time they perform their proper *Revolutions* about their *Primary Planets*, and therefore they will have the same *Phases* and *Figures* when viewed from *Saturn* and *Jupiter*, that our *Moon* shews us. When they are in *Opposition* to the *Sun*, they appear to *Saturn* and *Jupiter* bright and full; when they

they come to *Quadrantal Distance*, they look like *Half Moons*; before the *Conjunction*, they shew themselves in *horn'd Figures*, and when they come to be joyned in the same Line with the *Sun*, they totally disappear.

To explain the *Phenomena* of the *Satellites*, let A B T (Fig. 15. Plate 6.) represent the *Orbit* of the *Earth*, S the *Sun*, and let x y be a Portion of *Jupiter's Orbit*, in which, let *Jupiter* be in 4, the *Center* of his four *Attendants*; these *Satellites* or *Moons*, when they describe the *Superiour* Parts of their *Orbits* G H R, they are twice hid from us, viz. once by the *Interposition* of *Jupiter's Body* betwixt them and us; that is, when they happen to be in the right Line, which joins the *Centers* of the *Earth* and *Jupiter*: And again, they vanish and become invisible, when they fall into the *Shadow* of *Jupiter*; which is, when they are in a right Line that joyns the *Centers* of the *Sun* and *Jupiter*, and then they suffer *Eclipses*, which is always when they are at their *Full*, as seen from *Jupiter*. These *Eclipses* happen after the same manner as that of
our

Fig: 12.



Fig: 13.



Fig: 14.

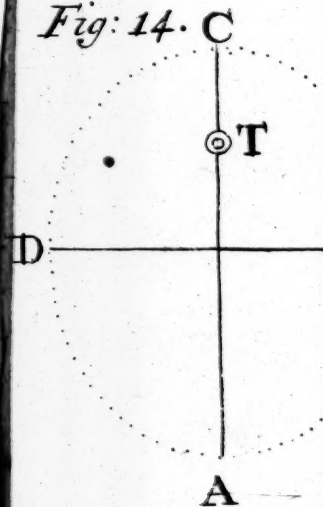


Fig. 11.

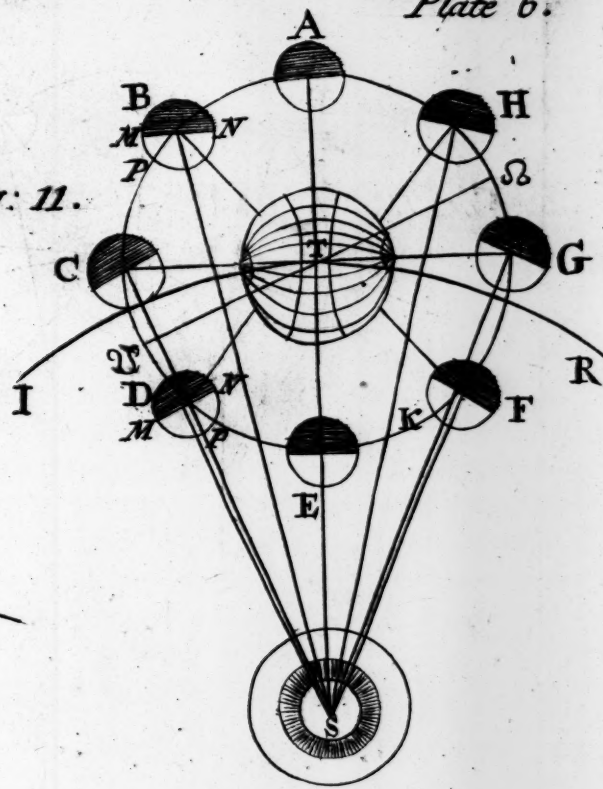


Fig. 13.

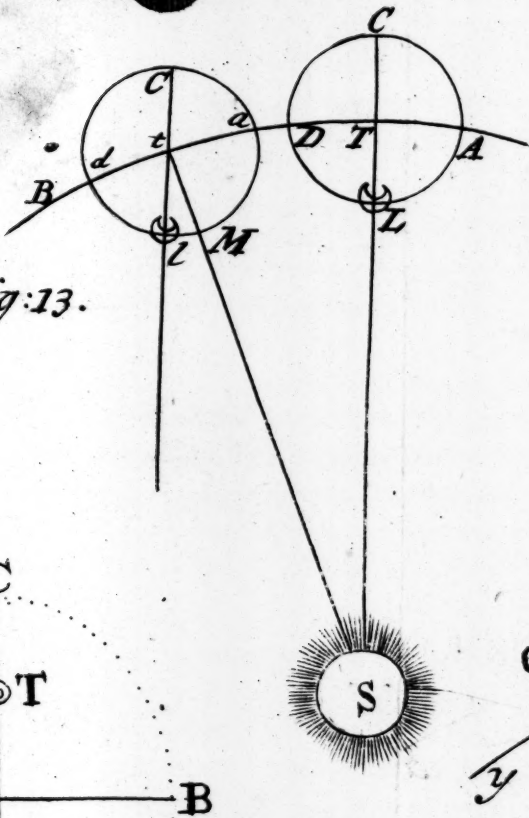
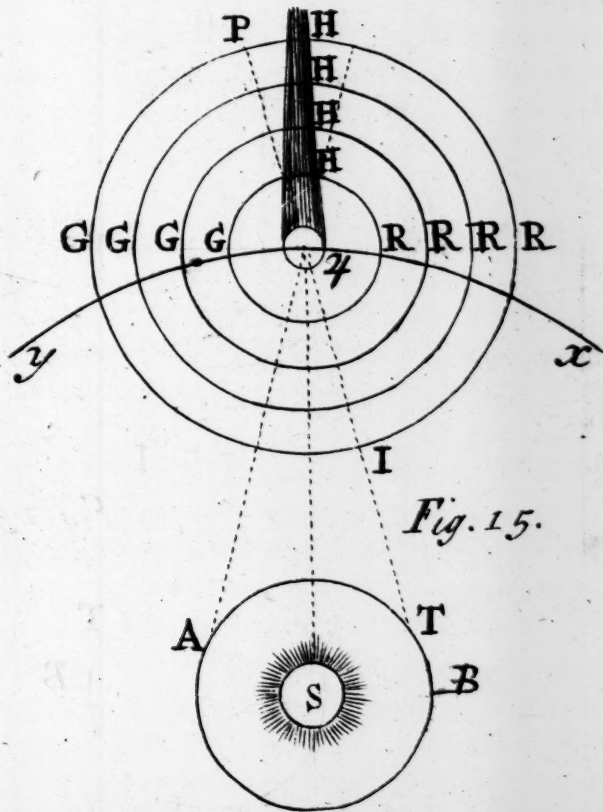


Fig. 15.



our *Moon*, by the Interposition of the *Earth* between the *Sun* and it.

When *Jupiter* is to the *East* of the *Sun*, and is seen in the Evening after *Sun* setting, they are hid behind *Jupiter*, because of their visible Conjunction with him before they fall into his *Shadow*: and their second disappearing is in the *Eclipse* upon their entering the *Shadow*.

And when *Jupiter* is more *Westerly* than the *Sun*, and is only seen in the Morning, then they fall into *Jupiter's* *Shadow* at H, and are *eclipsed* before they are hid behind his Body at P. But when these *Moons* have a *retrograde* Motion; that is, when they are seen to go *Westward*, and describe the inferiour Parts of their *Orbits*, then they only disappear at I, when they can't be distinguished from the Body of *Jupiter*.

When the *Satellites* seen from the *Sun*, are in their *inferiour Conjunction* with *Jupiter*, or as seen from *Jupiter*, in *Conjunction* with the *Sun*, their *Shadows* will fall upon *Jupiter*, and some Part of *Jupiter's* *Disk* will suffer an *Eclipse*, and a *Spe&ator* within the *Shadow* would observe a *total Eclipse* of the *Sun*.

All the *Planets Secondary* as well as *Pri-
mary*, observe a wonderful *Harmony*, and
Proportion to one another in the Times
they take to finish their *Revolutions*, for
the nearer any *Planet* is to the *Sun* (or to
the *Center* of his *Motion*) the sooner does
he finish his *Circulation*, and his *Motion*
is the quicker ; and in this there is a con-
stant and *immutable Law*, which all the
Bodies of the *Universe* inviolably observe
in their *Revolutions*, viz.

That the Squares of their Periodical
Times are as the Cubes of their Distances
from the Center of their Orbits, about
which they perform their Motions regu-
larly.

Now their Periods and Mean Distances
are as in the following Table.

	The Periods.			Mean Distances.	
	Days.	Ho.	'	"	
h	10759	6	36	26	953800
♃	4332	12	20	35	520110
♄	686	23	27	30	152369
♅	365	5	49	20	100000
♆	224	16	49	24	72333
♇	87	23	15	53	38710

By making Tryal it will appear, that the Square of *Saturn's Periodical Time*, is to the Square of *Jupiter's*, as the Cube of *Saturn's* Distance from the *Sun*, is to the Cube of *Jupiter's* Distance; and as the *Periodical* Motions of the *Planets* are regulated by one general Law, so they are likewise retained in their own *Orbits*, after an uniform Manner by one Sort of Force, which makes them tend to the *Center* of their *Orbits*, and is thence called the *Centripetal Force*, or in a Word, *Gravity*; for which we are indebted to the incomparable *Sir Isaac Newton*, he having demonstrated, that any Body when put in Motion, will move Uniformly in a strait Line, if not hindred, by which it appears, that any *Planet* would fly out of its *Orbit* in a right Line (which is a *Tangent* to its *Orbit*) was it not acted upon, or pull'd back and retained in its *Orbit*, by *Gravity*, in which appears the Excellency of the *Copernican System* above any other; for as much as this *System* may be preserved by *Gravity* alone, uniformly propagated through the *Universe*; whereas all the other *Systems* require some

one or more) other Forces, besides that of *Gravity*.

And seeing all Bodies act upon one another according to the Quantity of Matter they contain, it will appear from the following Table, that the Sun, which is 116 times bigger than all the *Planets* put together, must be the Body to which the other *Planets* gravitate, or the Center about which they perform their Motions, and by whom they are retained in their *Orbits*.

The *Diameter* of the *Sun* is to the *Planets Diameters* nearly in the Proportion represented in the following Table.

The Diameter of the Sun is to the Diameter of	$\left\{ \begin{array}{l} \textit{Saturn,} \\ \textit{Jupiter,} \\ \textit{Mars,} \\ \textit{The Earth,} \\ \textit{Venus,} \\ \textit{Mercury.} \end{array} \right\}$	as 1000 is to	137
			181
			6
			12
			12
			4

And

And because Spheres are to one another as the Cubes of their Diameters,

The Sun will be to	{	<i>Saturn,</i>	as 1000000000 is to	{	2571353
		<i>Jupiter,</i>			5929741
		<i>Mars,</i>			216
		<i>The Earth,</i>			1728
		<i>Venus,</i>			1728
		<i>Mercury.</i>			64

The Quantity of Matter in *Saturn* is 2400 times less than the Matter of the *Sun*; *Jupiter*, the biggest of all the *Planets*, the Matter that composes his Body is 1033 times less than the Matter of the *Sun*: But our *Earth*, if compar'd with the *Sun*, is but of a very small Magnitude, and not bigger than a Physical Point, for it is 500000 times less than the *Sun*, *Jupiter* is about 2000 times bigger than our *Earth*, *Venus* is of the same Magnitude with our *Earth*, but *Mars* and *Mercury* are less than our *Earth*.

S E C T. VIII.

Of the Annual Motion of the
E A R T H.

THE *Earth* which we inhabit, is one of those *Planets* which moves round the *Sun*, performing its *Revolution* in the Space of a Year, or 365 Days, 5 Hours, and 49 Minutes, and at the same time turns round its own *Axis* every 24 Hours.

To explain the *Annual Motion* of the *Earth*, Let A B C D, &c. Fig. 16. Plate 7. represent the *Orbit* of the *Earth*, in which it is carried from *West* to *East* in the Compass of a Year, and γ , δ , Π , &c. the apparent *Annual Path* of the *Sun* among the fixed Stars, which let be divided into 12 equal Parts, and the several Lines S A, S B, S C, &c. being drawn, will divide the *Orbit* of the *Earth* into 12 unequal Parts.

A Spectator

A *Specſator* in S (the Sun) obſerving the *Earth* in A, it will appear to him among the fixed Stars, viz. γ , and in its Mean Diſtance from the Sun, the *Earth* moving forward in its *Annual Motion* from A to B, and from B to C and D, the *Specſator* in S, will ſee the *Earth* move forward among the fixed Stars from γ to δ , from δ to π and ϵ , in which Point it will appear in its *Perihelion*, or neareſt Diſtance from the Sun; and the *Earth* continuing to move forward in its *Orbit* from D, through DEF, the Obſerver in S, will ſee it deſcribe in that Time, the ſucceeding *Quadrant* of the *Ecliptick*; that is, ϵ , ρ , μ , and in ω will obſerve the *Earth* again in its Mean Diſtance from the Sun. Alſo while the *Earth* paſſes through GHI, the Obſerver will ſee it among the Stars ω , μ , τ , and at K the *Earth* appears then in its *Aphelion*, or in its *greateſt* Diſtance from the Sun, and ſo continues to move through KLM, which makes it appear from S, to be with the Stars ν , ω , κ , which brings it to γ again, being one intire *Revolution* round the Sun.

The

The *Spectator* having viewed the *Annual Motion* of the *Earth* from the *Sun*, the Center of that *Motion*; let us now bring him from thence to our *Earth*, and let him be carried by it round the *Sun*, and let us *imagine* the *Earth* in G, the *Spectator* sees the same Face of the *Heavens*, and the very same *Constellations*, as we have said before, he did while he was in the *Sun*, the only Difference will be, that as before he *imagined* the *Sun* in the *Center*, and the *Earth* in the *Heavens*, he will now suppose the *Sun* in the *Heavens*, and himself with the *Earth* at Rest in the *Center*; and the *Observer* being carried along with the *Earth*, and partaking of the *Annual Motion* common to them both, he will observe all the Parts of the *Earth* and all the *Bodies* fixed on its *Surface*, to keep the same Distance with respect to one another, and to his own *Eye*, and therefore he cannot by his own *Eye*, perceive either his own *Motion*, or that of the *Earth*. But observing the *Sun*, when the *Earth* comes to K, he will see the *Sun* with the *Stars* ☿, and will perceive that he has chang'd his Place among the *Stars*, and that he has moved from γ to

ϑ and π to $\mathfrak{S}$, and while the *Earth* goes on in its *Progress* to M, the *Sun* will be seen from thence to have moved through the Signs $\mathfrak{S}$, $\mathfrak{Q}$, $\mathfrak{W}$; and again, while the *Earth* describes the *Semicircle* A B C D E F, the *Sun* will appear to have moved in the *concave Surface* of the *Heavens* through the six Signs $\mathfrak{=}$, $\mathfrak{m}$, $\mathfrak{r}$, $\mathfrak{v}$, $\mathfrak{w}$, and $\mathfrak{x}$, and therefore an *Inhabitant* of the *Earth* observes the *Sun*, which is really *immoveable*, to go through the same *Circle* in the *Heavens*, and in the same *Space* of *Time* that a *Spectator* in the *Sun* would see the *Earth* describe that *Circle*. Hence arises that *apparent annual Motion* of the *Sun*, by which it is observed to go forward every *Day* by little and little towards the *Eastern Stars*. So that any *Star* near the *Ecliptick* that rises when the *Sun* rises, after some *Days* the *Star* will rise before the *Sun*, the *Sun* having got to the *Eastward* of it; So likewise a *Star* that is seen after the *Sun* sets at a considerable *Distance* from him, in the *Space* of some few *Days*, will set with the *Sun*; and after that, will rise before him in the *Morning*, and set before him at *Night*.

The

The *Revolution* of the Earth about the Sun is not *Circular*, for the great *Kepler* by a most certain and infallible Method of *Reasoning*, has shewn, that the Motion of the Earth (as of all the other *Planets*) is performed in an *Ellipse*, having the Sun in one of the *Focusses*, and that its Motion in this *Ellipse* is really unequal, sometimes *quicker*, and sometimes *slower*; and that according to its Distance from the Sun.

The *Axis* of the *Ellipses* A P (Fig. 17. Plate 7.) is called the Line of the *Ap-sides*; the Point A, is termed the *Aphe-lion*, and P, the *Perihelion*; and S C the Distance between the Sun in the *Focus* and the *Center*, is called the *Excentricity*. If from the *Center* C, there be erected upon the *Axis* the Perpendicular CE, meeting with the Orbit in E, and there be drawn from the *Focus* the Line SE, this Line is call'd the Mean Distance of the Planet from the Sun, which is equal to half the *Axis*, it exceeding the shortest Distance S P, as much as the longest Distance S A exceeds it.

In

In the *Orbit* of the Earth, the *Excentricity* SC is only 17 of such Parts as SE the Mean Distance consists of 1000.

The Motion of the Earth is not at all equal, yet it is *regulated* by a certain immutable Law, from which it never deviates; which is, that a Line or Ray drawn from the Center of the Sun to the Center of the Earth, does so move, that it describes an *Elliptick Area* about the Sun, always proportional to the Time: And this Law holds in all the *Primary Planets*: Thus, let the Planet be in A , from whence, in a certain Time, let it go to B , the Space or *Area*; the Ray SA , describes the Figure ASB ; again, when the Planet comes to P , from which Point, suppose it to move through the *Arch* PD in the same Space of Time that it did thro' the *Arch* AB , which *Arches* must be unequal, and nearly in a *reciprocal Proportion* to their Distance from the Sun, because of the *equal Areas*; the *Arch* PD must be so much in Proportion greater than the *Arch* AB , as SA is greater than SP . This Law is sufficiently demonstrated by the most learned *Kepler*, and unto this his *Invention* all the *Astronomers*

do now give their *Affent*; for there is no other *Rule*, which so well satisfies for all the *Appearances* of the *Planets Motions*.

The Earth being farthest from the Sun in our Summer, (as appears by Fig. 16. Plate 7.) so that when the Sun appears in *Cancer*, the Earth is in K, its greatest Distance from the Sun, it may be asked, Why the Earth grows warmer while it is still removing farther from the Sun: And again, in the Winter, Why it should be cold, notwithstanding its nearer Access to him? To answer which, 'tis to be observed that the Sun being low in the *Horizon* all the Winer, the Beams pass thro' a much greater *Quantity* of *Air*, or is deeper *immersed* in our *Atmosphere* in Winter than in Summer, when the Sun approaches nearer to our *Vertex*; and the Difference is so very great, that when the Sun is near the *Hcrizon*, we can look upon him without hurting our Eyes, the Force of the Rays being broke by the Reflection on, and Refraction by so many Particles of the denser *Air*.

Another Cause which produces the Variety of *Seasons* is, that in Summer the Day being longer than the Night, we receive

ceive a greater Quantity of Heat from the Sun, than can be removed in the short Night; and this Heat encreaseth with the Length of the Day, and continues so to do after the longest Day, till the Sun return almost to the *Equator*.

The Inhabitants of the other *Planets*, will observe such Motions in the Sun, as we do from our Earth, *viz.*

An Inhabitant of *Jupiter* will think that the Sun turns round their Earth in 12 of our Years; that *Circle*, which the Sun, by his *Annual Motion* appears to them to describe, is not the same with our *Ecliptick*, by reason of the *Latitude* of *Jupiter*. And for the same Reason, the Sun seen from *Saturn* will appear to move in another Circle distinct from either of the former, finishing his *Revolution* in about 30 of our Years.

Also, from *Mars*, he will appear to describe a *Circle*, different from either of the former, in two of our Years; Since it is impossible that the Sun can have all these Motions really in itself, and there can be no Reason given why any of them should belong really to the Sun

more than the rest: We may therefore *reasonably* affirm, that there are none of them real, but that they are all apparent, and arise from the Motions of the respective *Planets*.



SECT.

S E C T. IX.

Of the Inequality of Days and Nights.

TO explain the Variety of the Days and Nights, and the Seasons of the Year; suppose the Earth in ∞ (Fig. 18. Plate 7.) in its *Orbit*, carried from *West* to *East*, revolving at the same time about its own *Axis* in twenty four Hours from *West* to *East*, P will represent the *North Pole*, and O the *South*, E Q the *Equator*, whose *Plane* is inclined to the *Plane* of the *Ecliptick* by an *Angle* of $23\frac{1}{2}$ Degrees. It is plain, if the Earth be in *Aries* or *Libra*, where the Rays joyning the Sun and Earth's Centers, cut perpendicular its *Axis* P O, the Sun will appear in the *Equinoctial Circle*, and consequently declines neither to the *North* or *South Pole*, but seems to describe in its diurnal Motion, the *Equator* itself: In which Situation the *Illumination* of the Earth made by the Sun, extends it self to both *Poles* P O.

The

The *Axis* P O, which in this Case represents the *Horizon*; or that Circle which separates the *illuminated* from the *darkened Hemisphere*, divides the *Equator* and all its *Parallels* equally: And therefore any *Parallel* of the *Equator* being carried round by the equal *Diurnal Motion*, is as long in the *Darkness* as in the *Light*; that is, the Day and Night will then be equal all over the Earth, for Example, let L N represent the *Parallel* of *Latitude* for *London*, 'tis plain, that the said *Parallel* is equally divided by the *Circle*, separating the *enlightened* from the *darkened Hemisphere*, consequently the *Diurnal Arch* is equal to the *Nocturnal*.

Supposing now the Earth at *m*, the Rays of the Sun S *m* will not be perpendicular to the *Axis* of the Earth P O, but will meet with the same in some other *Parallel*, which will be between the *Equator* and the *Tropick of Cancer*; for the Earth in its *Annual Motion* being removed from the *Equator* about 10 Degrees, the Sun will then appear to have 10 Degrees of the *Northern Declination* equal to the Arch of the *Meridian* E x, therefore the Ray of the Sun

Sun will not meet with the Earth at E, the *Equator* but in x, from which Point draw x B parallel to the *Equator*, it will represent the *Parallel*, which the Sun appears to describe for that *Day*, by the *Diurnal Motion* of the Earth.

The enlightened *Hemisphere* being always 90 Degrees on each Side of the Circle the Sun appears to describe, he shall then shine to y, 10 Degrees on the other Side P the *North Pole*, and to u, 10 Degrees short of O the *South Pole*, and describing a Circle *parallel* to the *Equator* at the Distance Q y, the whole Tract betwixt that Circle and the *North Pole* P, shall have the Sun still in *View*, and consequently continual Day; it's plain that the like Space lying betwixt the Circle U a and the *South Pole* O, shall have continued *Darkness*; the Circle y u will represent the *Horizon*, being perpendicular to the Ray of the Sun S x: But in this *Position*, all the *Parallels* betwixt the *Equator* and the Circle y m towards the *North Pole*, are cut by the Circle y u bounding Light and *Darkness* into *unequal* Parts, the largest Parts of these Circles remaining in the *Light*, and the smallest in *Darkness*;

ness : But those *Parallels* that are toward^s the *South Pole*, as far as the *Circle* *u a*, have their greatest *Portions* in *Darkness*, and the least in *Light* ; and the *Difference* of these *Portions* will be greater or less according as the *Circles* are nearer to the *Pole* or to the *Equator* : Thus, in the *Parallel* of *London* *L N*, the *Diurnal Ark* is represented by *L c*, and the *Nocturnal* by *c N*; in which Case the *Diurnal Ark* is greater than the *Nocturnal* to all those on the *North Side* of the *Equator*.

In like manner, the *Earth* being at *z*, the *Point* of its greatest *Southern Declination*, the *Sun* will then appear to the *Northward* from the *Equator* 23 Degrees 29 Minutes equal to the *Arck* of the *Meridian* *E ☉*, and the *Ray* of the *Sun* *S ☉* shall meet with the *Earth's Surface* in *☉*, from which a *Line* drawn *parallel* to the *Equator*, will represent the *Parallel* which the *Sun* appears to describe for that *Day* by the *Diurnal Motion* of the *Earth*, which *Circle* is call'd the *Tropick* of *Cancer* ; and by the *Revolution* of the *Earth* round its *Axis*, all the *Points* of the *Parallel* *☉ ☉*, will pass directly under the *Point* *☉*, therefore will be directly under

the Sun, and the Sun will be *Vertical* to all the Inhabitants that are under the *Tropick of Cancer*, when he comes to their respective *Meridians*.

While the Earth is in this Position, it is manifest, that the *Circle* which bounds *Light* and *Darkness* reaches on the other Side of the *North Pole* P to y, but falls short of the *South Pole*, O, and reaches no farther than u; through ny, and u s let two *Parallels* of the *Equator* be described, these two *Circles* are called the *Polar Circles*, and while the Earth is in z, all that *Tract* of the *Globe*, that is included within the *Polar Circle* n y, continues in the *Light*, notwithstanding the *Revolution* of the Earth round its *Axis*, and the Inhabitants there enjoy a continued *Day*. On the contrary, those that lie within the opposite *Polar Circle* U S, remain in *Darkness*, having all Night without any *Day*.

It is likewise manifest, that all the *Parallels* between the *Equator* E Q, and the *Arctic Circle* n y, are cut by the *Horizon* y u into unequal Parts, the longest remaining in *Light*, and the shortest in *Darkness*. Thus, the Parallel of *London*

S

LN

L N, the *Ark* L c represents the *Diurnal*, and c N the *Nocturnal* Arch, therefore in this *Position* of the Earth, when the Sun is in ☊, the Inhabitants of the *North-ern Hemisphere* will have their Days at the longest, and their Nights the shortest, and the Season of the Year, will be *Summer*: But all those on the *South* Side of the *Equator*, will have their Nights the longest, and their Days the shortest, because the greatest Portion of their *Parallels* are in *Darkness*, and their least in the *Light*; the Season of the *Year* to them, at that time will be *Winter*. And in every Place, the Length of the longest Days are greater, according as the Place is farther removed from the *Equator*, and comes nearer to the *Pole*.

Also we see, that from the Time of the Sun's being upon the *Equator* at E, to the Time of his greatest *Declination* at ☊, the Sun has been continually in *View* of P and O has been still in *Darkness*; that is, for the Space of three *Months*, answering to the three *Signs* ♈, ♉, ♊: Also the *Pole* P, has the Sun still in *View* during the following Months, while he describes the three *Signs* ☊, ♊, ♋; for all this

this while he is on the *North* Side of the *Equator*: And the *Circle* bounding Light and Darknes falls on the other Side of the *North Pole*, but short of the *South*; so that the Inhabitants of the *North Pole* (if there be any) have their Day half a *Year* long, and those of the *South Pole* half a *Year* Night, viz. from *March* 10. to *September* the 13th, and on the contrary, when the Sun is to the *South* of the *Equator*.

It's evident, that of all the *Parallels*, there is only the *Equator* which is always cut into equal Parts by the *Circle* bounding *Light* and *Darkness*, being both of them great *Circles*; therefore it's only the Inhabitants of the Earth that live under the *Equator* which have their Days constantly equal to their Nights throughout the whole *Year*.

While the Earth goes forward from ♄ by ♃ and ♀ to ♄, during which Time, the *Sun* seems to move through the *Signs* ♄, ♃ and ♀; and returns towards the *Equator* till at last at ♄ the *Sun* appears in the *Equator* of the *Heavens*, because at that Time the Plane of the Earth's *Equator* produc'd does pass through the Center of the *Sun*, making the Days and Nights

over all the Earth equal; and now again the Extremities of *Illumination* reach to both *Poles*.

The Earth moving forwards thro' the Signs γ , δ , and π , the Sun will appear in the mean while to go thro' α , μ , and φ , and to decline gradually from the *Equator* towards the *South Pole*, till at last the Earth being in δ , and the Sun appearing in ν , all the *Phenomena* will happen to the Inhabitants of the *Southern Hemisphere*, as happen'd to them of the *Northern*, when the Earth was in ν , and what happened to them of the *Southern Hemisphere*, while the Earth was carried thro' ν , α , and κ , will now happen to them of the *Northern*, while the Earth is carried thro' δ , μ , and π , and the Sun will seem to move through ν , α , and κ , coming again to the Equator in γ , compleating the Year: And the Sun will cause the same *Phenomena* of Day and Night, the former decreasing, the latter increasing to the Inhabitants of the *Southern Hemisphere*, as it did to the Inhabitants of the *Northern Hemisphere*, while it went thro' the opposite Signs.

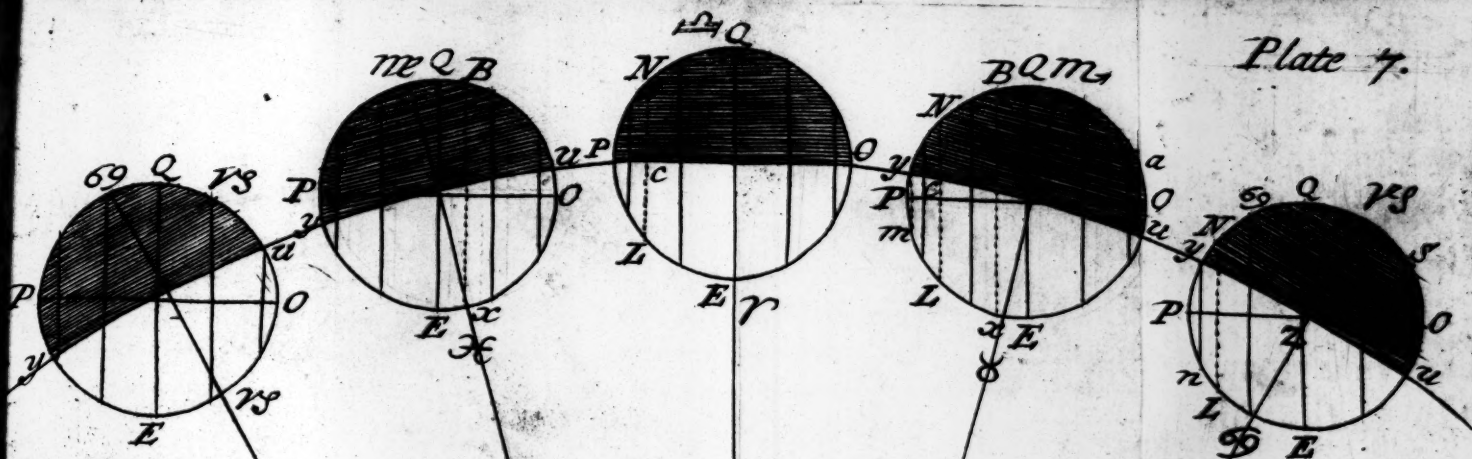


Fig:18.

Fig:16.

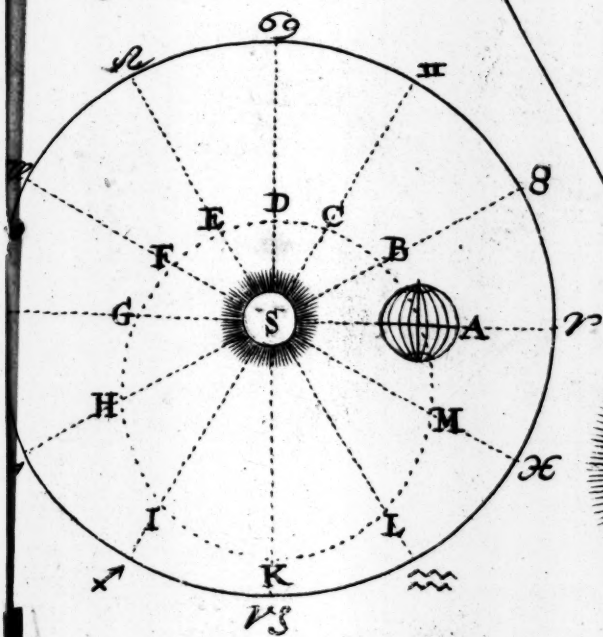
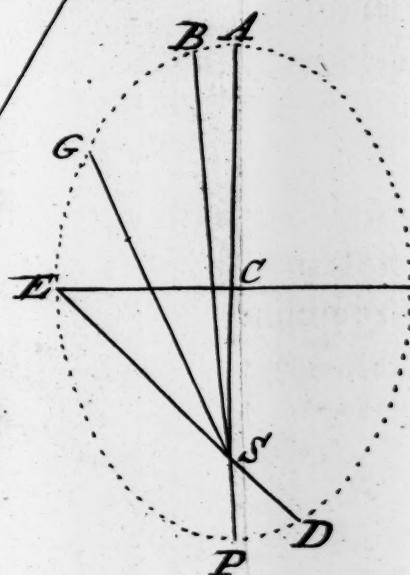


Fig:17.



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SECT. X.

*Of the Eclipses of the SUN
and MOON.*

THE Earth being an *Opaque* Body, and *enlightened* by the Sun, it casts a *Shadow* towards the Space opposite to the Sun ; and because the *Figure* of the Earth is *Spherical*, the *Figure* of the *Shadow* would be *Cylindrical* ; if the Earth and Sun were of equal Bigness, as in Plate 8. Fig. 19. or if the Earth were bigger than the Sun, the Shadow would have the *Figure* of a *Cone*, which had lost a Piece of its *Top* or *Vertex*, and the farther off from the Earth would be the *thicker*, as in (Fig. 20. Plate 8.) And in both these Cases the Shadow would be infinitely extended, and would *involve* sometimes the *Planets* *Mars*, *Jupiter* and *Saturn* within it, when they come to be in *Opposition* to the Sun, but this is never *observed* ; and therefore the Sun must be greater than the Earth, whose Shadow must be of a *Conical Figure*,

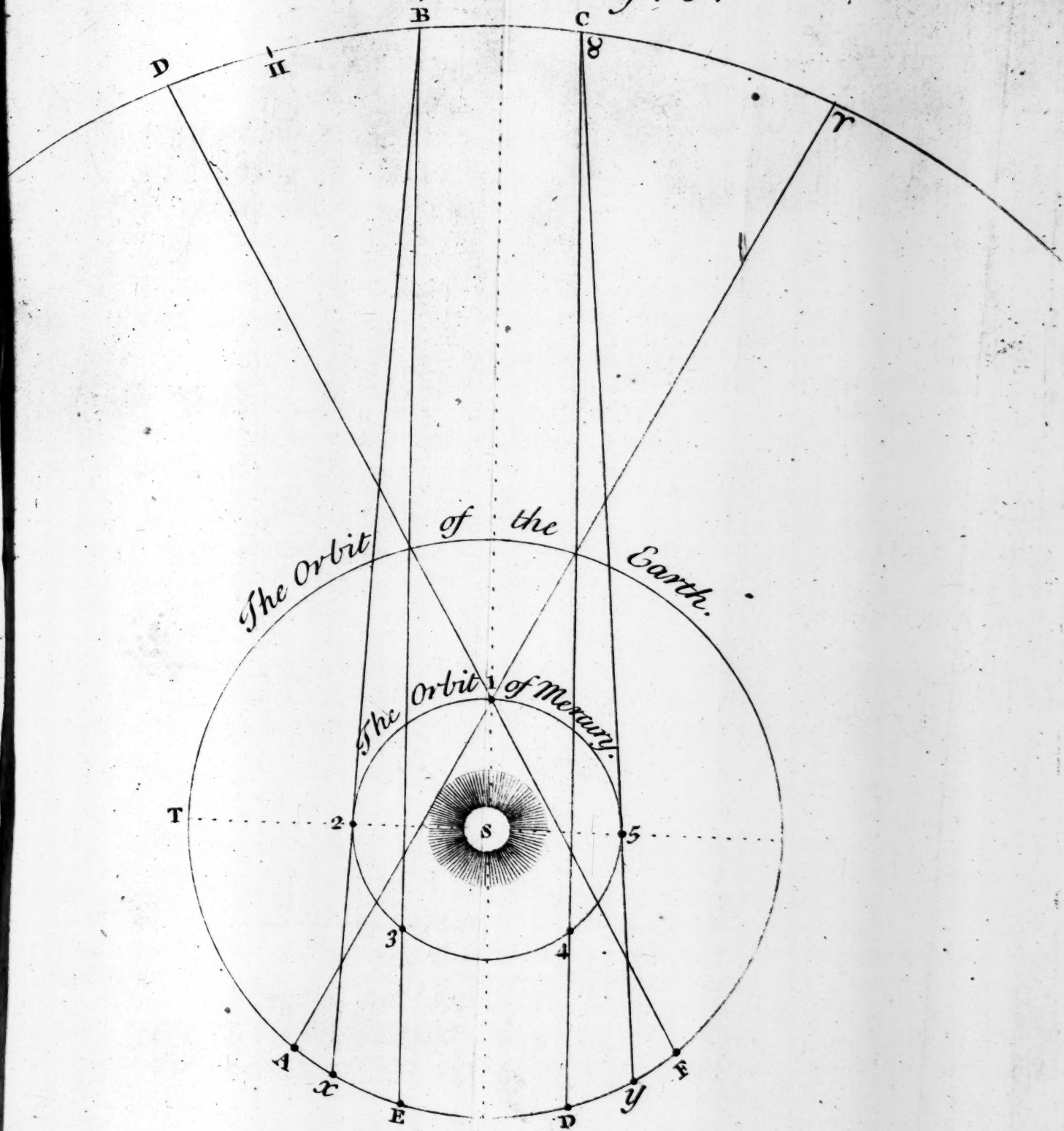
gure, and terminate in a Point, as in Fig. 21. Plate 8.

This Shadow of the Earth must always be in the Plane of the *Ecliptick*; since both Sun and Earth are always there. If at any time, when the *Moon* is in Opposition to the Sun, she should happen to be in the Plane of the *Ecliptick*, or pretty near it (which will be when the full Moon happens in or near a Node) it's evident that the Moon will be immerfed in the Earth's Shadow, and consequently deprived of the Sun's Light (as in Plate 9. Fig. 22.) by which it *shines*, that is, it will *suffer* an *Eclipse*, which will be *total* or *partial*, as a whole, or only a Part of the *Moon's* Body enters the Shadow.

Let the Line xy (Fig. 22. Plate 9.) represent the *Transverse Section* of the Earth's Shadow, where it crosses the Moon's Orbit. Let $\infty A \infty B$, be the Orbit of the Moon, $\infty C \infty E$ the *Ecliptick*, the Duration of some *Eclipse* is found to be so long as to let the Moon go the Length of 3 of its Diameters in the Shadow totally *Eclipsed*, which stay in the Earth's Shadow is computed to be about four Hours, whereof the Moon takes one Hour from its *Beginning*,

Plate 4th

Fig. 6.



ginning to enter the Shadow, till quite *immersed* therein, two Hours more she continues *totally dark*, and the fourth Hour is taken up from her first *Beginning* to come out of the Shadow, till she is quite out of it : And such an *Eclipse* is call'd a *Total* and *Central Eclipse*.

Sometimes the Moon is not arrived at, or has already pass'd the *Node*, when it's entering the Earth's Shadow; notwithstanding, if at that Time it be near the *Node*, it will be *totally immersed*, and consequently there will happen a *total*, though not a *Central Eclipse* (as in Fig. 23. Plate 9.) for the Way of the Moon A B, thro' the Earth's Shadow C D, is less than the *Diameter* of the Shadow E F, because it does not pass thro' its *Center*; and consequently will be pass'd through sooner.

But if it be so far off from the Shadow, as that only Part of the Moon is *immersed*, as it passes in its *Orbit* (y x Fig. 24. Plate 9.) the Shadow P O of the *Eclipse*, will be a partial one, and is said to be of so many Digits, as there are twelfth Parts of the Moon's *Diameter* darkened.

In all these Cases, in the Beginning of an *Eclipse*, the Moon enters the *Western* Part of the Shadow with the *Eastern* Part of her Limb, and in the End of it she leaves the *Eastern* Part of the Shadow with the *Western* Part of her Limb. The *Eastern* Limb, of the Moon in its Access to the Shadow, does not enter presently into the thickest *Darkness*, but grows darker and darker as it approaches *nigher* to the Shadow, and this arises from the *Penumbra*, which always accompanies a Shadow, which is made by a *Lucid* Body that is seen under a sensible Angle, thus (Fig. 21. Plate 8.) $xyAz$, represents the Shadow (where no Part of the Sun's Light comes) which is encompass'd all round with the *Penumbra* $YXP AZ$, where only some Part of the Sun's Light is intercepted by the Earth, and this *Penumbra* is more dim towards xy and zA the Edges of the perfect Shadow, because fewer Rays arrive thither; the *Portion* of the Sun from which they are emitted, being smaller, but less *obscure* towards xP , and ZN , where more Rays can reach, and beyond which *Limit* all the Rays of the Sun

Sun can come without any Hindrance at all.

Some kind of *Eclipse* or other of the Moon happens generally twice a *Year* at least, for there being 2 *Nodes*, in which the Moon's *Orbit* crosses the *Ecliptick*, which move contrary to the Series of the *Signs*, and the Earth going round the *Ecliptick* every *Year*, according to the Order of the *Signs*; hence it is obvious, that the Earth must meet the Moon's *Nodes* every *Year*. If therefore a full Moon happens *just* at that Time the Moon must *necessarily* be *totally* and *centerally eclipsed*; and though a full Moon does not happen *just* as the Sun and Node meet, yet the *Inclination* of the *Orbit* of the Moon to the *Ecliptick*, and the Depth of the Earth's Shadow is so great, that tho' the full Moon is distant above ten Days from the Time of the Sun's appearing in that Degree of the *Ecliptick* in which the *Node* is at that Time, either before or after it, and it can't be distant above *fifteen* Days, yet the Moon will scarce get *clear* of the Shadow, and consequently there will be at least a *Partial Eclipse*. But if the Earth happens to meet a *Node* of the Moon, on the very

Day of the *new Moon*, or one or two Days before or after, (which rarely happens) in this Case the *Moon* will be far enough to avoid the Shadow of the Earth, both in the foregoing, and also in the following *full Moon*, and so there will be no *Eclipse* of the Moon that half Year.

The *Moon* also being an opaque *Body*, and enlightened by the Sun, consequently casts a Shadow towards those Parts that are turned from the Sun. And if the Earth should be deprived of the Sun's Light, by being *immersed* in the Shadow of the *Moon*, this *Phenomenon* ought to be call'd an *Eclipse* of the Earth: But the Observer of it being on the Earth, and the Moon (which more or less covers the Sun) not being easily perceived by us, the Defect of Light *appears* to us as in the Sun it self; and is therefore called an *Eclipse* of the *Sun*, which is also *distinguished* into a *Total Eclipse*, wherein the Moon covers the whole Body of the Sun from us, or a *Partial Eclipse*, wherein the Moon covers only a Part of the Sun.

But it is to be *observed*, that altho' an *Eclipse* of the Sun be, in reality an *Eclipse* of the Earth, yet what is called a *Total Eclipse*

Eclipse of the Sun, is not to be conceived in reality, as a *Total Eclipse* of the Earth, or that the whole upper and *opposite Hemisphere* of the Earth is then deprived of the Sun's Light, as in a *total Eclipse* of the Moon its whole *opposite Hemisphere* is *darkened*. The Reason of which *Difference* is this: the Earth being bigger than the Moon, the Cone of its Shadow is big enough to involve the whole *opposite Hemisphere* of the Moon in its Darkness, whereas the Moon being less than the Earth, the Cone of her Shadow will involve at once, only a small Tract A B (in Fig. 25. Plate 9.) of the *opposite Hemisphere* of the Earth, so as to hide the whole Sun from the Inhabitants thereof, and consequently there will *appear* only to these a *Total Eclipse* of the Sun, whilst to the Inhabitants of the adjoining Tract B C, the Sun will appear to be but *partially eclipsed*; at the same time in other Places of the same *Hemisphere* as E F there is no *Eclipse* at all, the Sun enlightening without any Hindrance or *Impediment*.

The Height of the Moon's Shadow may be found by *Calculation*, to be about 59, 36 *Semidiameters* of the Earth; hence,

T 2

if

if the Distance of the Moon from the Earth be greater than her Mean Distance 60 Semidiameters of the Earth, the Shadow of the Moon cannot reach the *Earth*, in which Case there may be a *Central Eclipse* of the Sun, but not a *Total* one, but round the Moon there will appear a Part of the Sun's Body in the Form of a *Luminous Circle*, which like a bright shining *Ring of Gold*, will embrace the *Body* of the Moon.

The Bigness of a *Solar Eclipse* is to be estimated the same Way as in a *Lunar Eclipse*, by the Digits, or 12th Parts of the Sun's *Diameter* that are *darkened* by the Moon, at the middle Time of an *Eclipse*.

It's likewise evident, that the Moon moving towards the *East* (as in Fig. 25. Plate 9.) the *Western* Part of the Earth will be in the Shadow first; which will pass along the Earth's *Disk* like a *Spot*, through A B C E to F, where it leaves the Earth; but if the Moon be viewed from the Earth, the *Eastern Limb* of the Moon will first cover the *Western* of the Sun, and the *Western Limb* of the Moon will last uncover the *Eastern* of the Sun, and the greatest *Darkness* that can happen in a *Total*

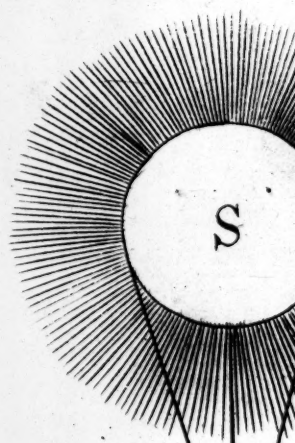


Fig: 25.



Fig: 24.

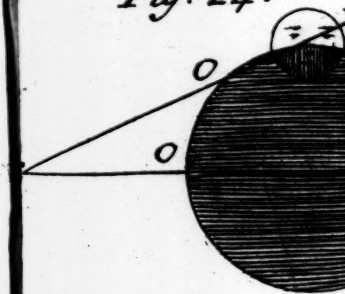




Fig. 22.

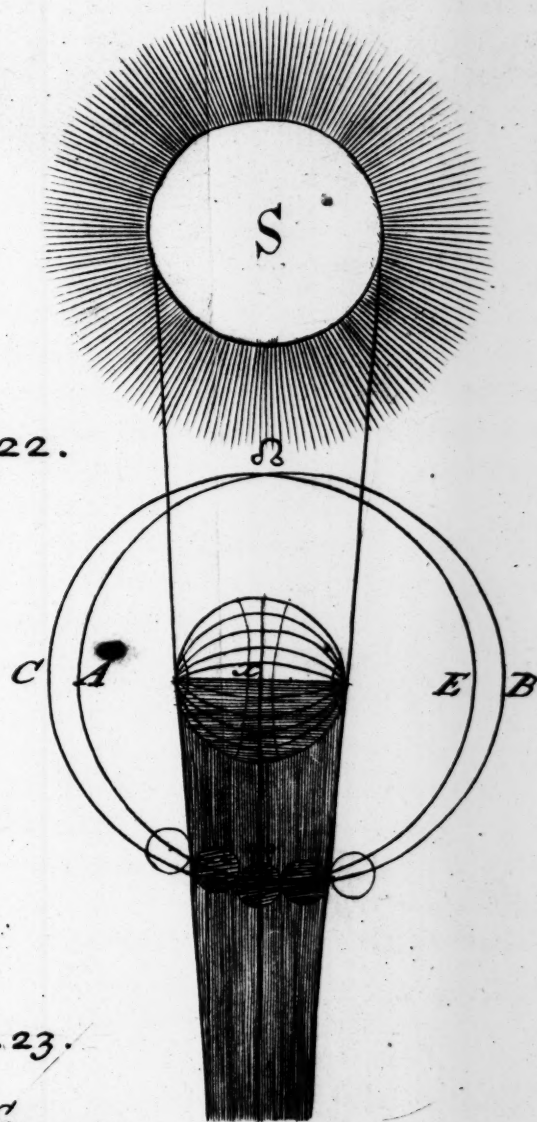
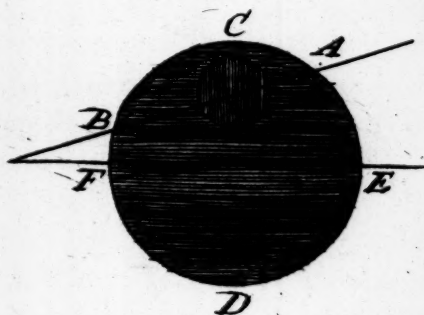
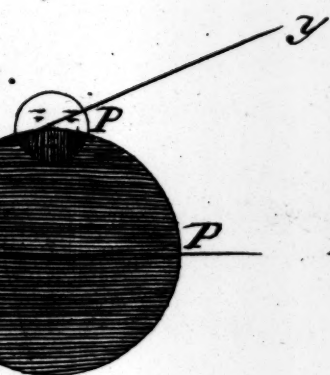


Fig. 23.



Total Eclipse of the Sun, is soon at an End, some Part of the Sun's *Disk* being presently uncovered, and that Part, tho' never so little, will mightily enlighten those Inhabitants of the Earth, to whom it is visible. Tho' the Moon must be in a *Node* the very Moment of the *new Moon*, to cause the greatest *Eclipse* of the Sun that can happen; and that the Shadow of the Moon may go along the Middle of the Earth; yet, if she be not far off from thence, the Shadow of the Moon, or at least Part of the *Penumbra* will fall upon some Tract of the Earth, being so big as to cause there a *Total*, or at least a *Partial Eclipse*; and in this Sense there are more *Eclipses* of the Sun than of the Moon; but in respect of any one given Place of the Earth, there are much fewer *visible Eclipses* of the Sun than of the Moon, for the Shade of the Moon is less than the Shade of the Earth, and consequently the former will not so often *involve* any given Place of the Earth, as the latter will some Part of the Moon.

S E C T. XI.

*Of the Solution of Spherical
Triangles upon the Globe.*

S*Spherical Triangles* are best represented by the *Circles* on, and those *appendant* to the *Globes*: The *Globe* being the *Original* from whence all *Spherical Trigonometry* proceeds, and upon which the *Sides* and *Angles* of all *Spherical Triangles* are most naturally represented and most expeditiously measured.

Definition I. A *Spheric Triangle* is bounded by the *Arcs* of three great *Circles* of the *Sphere*, or *Globe*, each *Arc* being less than a *Semicircle*, or 180° .

Def. II. A *Spheric Angle* is the same with the *Inclination* of the *Planes* of those two *Circles* which constitute the *Angle*; and if from the *Point* of any *Spheric Angle* as a *Pole*, you describe a *Circle* at the *Distance* of 90° from that *Point*, the *Arch* of this *Circle* intercepted between the
Legs

Legs of the Angle, is the Measure of it.

Def. III. When a *Spherical Angle* has one or more right Angles; that is, contains 90 Degrees, it's call'd a *right Angled Spherical Triangle*: If all its Angles be acute, that is, each of them less than 90° , it's call'd an *acute Angled Triangle*; and if all its Angles be *obtuse*, each exceeding 90° , or if some of them be *obtuse* and some *acute*, it's called an *obtuse Angled Spherical Triangle*.

Def. IV. The *Complement* of a Side or Angle to a *Quadrant*, or 90 Degrees, is so much as that Side or Angle wants of 90 Degrees; and their *Complement* to a *Semi-circle*, is so much as that Side or Angle wants of 180 Degrees.

Def. V. If two great *Circles* of the *Sphere* pass through each others *Poles*, those two great *Circles* intersect each other at *Right Angles*; But if they intersect each other, and do not pass through each others *Poles*, those two *Circles* shall intersect each other at *oblique Angles*.

Def.

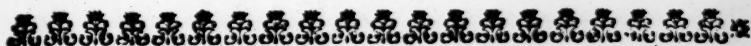
Def. VI. If a *Spherical Triangle* have three *Right Angles*, the three Sides of that *Triangle* shall be all *Quadrants*, as in a *Parallel Sphere*, the brass *Meridian* cutting the *Horizon* in *North* and *South* at *Right Angles*, the *Equinoctial Colure* cutting the *Horizon* in the *E.* and *W.* Points at *Right Angles*; and the *Meridian* and *Colure* intersecting each other in the Poles of the *World* at *Right Angles*; do constitute a *Spherical Triangle* with three *Right Angles*; and the three Sides of this *Triangle* (for this Reason) shall be all of them *Quadrants*.

Def. VII The Sides of *Spherical Triangles* are of the same Affection or Kind with their opposite Angles.

Def. VIII. All great *Circles* must cut each other in two equal Parts, because their common Intersection is a *Diameter* of the *Sphere*, and consequently the two Points of Intersection are at the Distance of a *Semicircle* from each other.

Def. IX.

Def. IX. The opposite *Angles* at the Intersection of two *Circles*, are always equal, because the same *Plane* constitutes both *Angles*.



C A S E I.

In the *Right Angled Triangle* H O P,
Right Angled at H, Fig. 1. Plate 10.

Given	{	P H the <i>Latitude</i> of	51	30
		the Place - - -		
		P O the <i>Sun's</i> Distance		
		from the <i>Pole</i> , or the <i>Com-</i>	70	30
		plement of his <i>Declination</i>		

Required	{	H O the <i>Complement</i> of the	
		<i>Sun's Amplitude.</i>	
		H P O the <i>Hour</i> of the	
		<i>Sun's</i> rising accounted from	
		<i>Midnight.</i>	
		P O H the <i>Angle</i> of the	
		<i>Sun's Position.</i>	

To represent this *Triangle* on the *Globe*.

Elevate the Pole to the given *Latitude*, and turn the *Globe* about till $70\frac{1}{2}$ Degrees of the *Equinoctial Colure*, counted from the Pole, be at the *Horizon*; so will the *Triangle* be perfectly described by an *Arch* of the brass *Meridian*, an *Arch* of the *Horizon*, and an *Arch* of the *Colure*.

The Complement of the Sun's *Amplitude* H O, is numbred on the *Horizon*, from the *Colure* to the *North Point* of the *Horizon*, and in this Case is $57^{\circ} 34'$.

For the Angle H P O, count the Degrees of the *Equinoctial*, which are contained between the *Colure* and the *North Side* of the brass *Meridian*, which Degrees reduced to Time, by allowing 15° to an *Hour* gives the Time of Sun-rising, and in this Case will be 62 Deg. 45 Min. or 4 Hours 11 Minutes; the Hour from *Midnight*.

And for the Angle P O H, number on the *Colure*, and also on the *Horizon* (the Sides that include the Angle) 90 Degrees from the *Angular Point*, and the Distance between those two Points where the Reckoning ends, measured by the *Quadrant*
of

of *Altitude*, or by *Compasses*, contains
56 Deg. 39 Min.



C A S E II.

In the Right-Angled *Triangle* $x y z$, Right
angled at y , Fig. 2. Plate 10.

Given { $x z$ the Sun's Distance from the
next *Equinoctial* Point *Aries* 72° .
 $y x z$ the Angle that the *Eclip-*
tick makes with the *Equator*, being
the Sun's greatest Declinat. $23^\circ 29'$.

Requi- { $z y$ the Sun's present Declina-
red { tion.
 $x y$ the Sun's right Ascension.
 $y z x$ the Angle that the *Meri-*
dian makes with the *Ecliptick*.

To represent this *Triangle* on the
G L O B E.

Bring the Sun's Place (which in this
Example is the 12th Degree of *Gemini*) to
the brazen *Meridian*, and fix the *Globe*
in that Position, and the *Triangle* will be
represented by an *Arch* of the *Equator*,

an *Arch* of the *Ecliptick*, and an *Arch* of the brazen *Meridian*.

The Sun's present Declination $z y$ is measured on the brazen *Meridian*, and in this Case is $22^{\circ} 16'$.

The Sun's Right Ascension $x y$ is measured on the *Equator*, and from the first of *Aries*, and in this Case is 70 Deg. 29 Min.

And for the Measure of the Angle $y z x$, number 90 Degrees on the *Meridian* from the Sun's Place, and 90 Degrees on the *Ecliptick* from the same Place, so shall the Distance between these Points (measured by the *Quadrant* of *Altitude*, or by *Compasses*) contain for the Angle $y z x$, 82 Deg. 20 Min.



CASE

C A S E III.

In the Right Angled *Spherical Triangle*
A O B, Right Angled at B, Fig 3. Plate
 10.

Given { **O A B** the Complement of *La-*
titude - - - - - $38^{\circ} 30' N.$
B O the Sun's Decli- }
nation North - - - $20 \quad 30$

Requi- { **A O** the Sun's *Amplitude*
 red { from the *East* or *West* Points of
 the *Horizon*.
A B the *Ascensional* Differ-
 ence.
A O B the Angle of the Sun's
 Position at his rising.

To represent this *Triangle* on the
G L O B E.

Depress the *Equator* below the *North*
 Point of the *Horizon* $38^{\circ} 30'$ the Comple-
 ment of the *Latitude*, then number the
 Sun's Declination 20 Deg. 30 Min. on the
Equinoctial Colure, and bring that to the
East

East Side of the Horizon; so shall the *Triangle* be formed and appear below the *Horizon*, by A O, an *Arch* of the *Horizon*, AB an *Arch* of the *Equinoctial*, and BO an *Arch* of the *Colure*.

The Parts required of this *Triangle* are found thus :

A O the Sun's *Amplitude* from the *East*, is numbred on the *Horizon* to the *Colure*, and is 34 Deg. 14 Min.

A B the *Ascensional Difference* is numbred on the *Equator* from the *East Point* of the *Horizon* to the *Colure*, and is 17 Deg. 18 Min.

And the Angle of the Sun's *Position* A O B is found by continuing the Sides O A and O B, to *Quadrants*, and then measuring betwixt those two Points, as in the first and second Cases.



C A S E IV.

In the *Right Angled Triangle A E L*,
Right Angled at E, Fig. 4. Plate 10.

Given $\left\{ \begin{array}{l} A L \text{ the Sun's De-} \\ \text{clination} \quad - \quad - \quad - \end{array} \right\} 20^{\circ} 30' N.$
 $\left\{ \begin{array}{l} L A E \text{ the } Lati- \\ \text{tude} \quad - \quad - \quad - \quad - \end{array} \right\} 51 \quad 30 N.$

Requi- $\left\{ \begin{array}{l} L E \text{ the Sun's } Altitude \text{ at} \\ \text{red} \quad \text{fix} \\ A E \text{ the Sun's } Azimuth \text{ from} \\ \text{the } East, \end{array} \right.$

To represent this *Triangle* on the
G L O B E.

Elevate the *Pole* to the given *Latitude*
 fix the *Quadrant* of *Altitude* in the *Zenith*,
 and number the Sun's Declination 20 deg.
 30 Min. on the *Equinoctial Colure*; the
Colure being brought to the *East Point*
 of the *Horizon*, bring the graduated *Edge*
 of the *Quadrant* over the Sun's Declina-
 tion

tion on the *Colure* : So will the *Triangle* be formed by A L an *Arch* of the *Colure* equal to the *Declination* A E an *Arch* of the *Horizon*, equal to the *Azimuth* numbred from the East : And,

L E an *Arch* of the *Quadrant* of *Altitude*, in which Case L E the Sun's *Altitude* is 15 deg, 54 min.

A E the Sun's *Azimuth* from the East 13 deg. 6 min.



Of Oblique *Angled* Spherical Triangles.

C A S E I.

In the *Oblique Angled Spherical Triangle* P Z M (Fig. 5. Plate 10.) *Oblique Angled* at Z.

Given	{	Z P the Complement of the <i>Latitude</i>	}	38°	30'			
		M P the Sun's Distance from the <i>Pole</i> being the Complement of his Declination				}	70	00
		M Z the Complement of the Sun's <i>Altitude</i> , or his Distance from the <i>Zenith</i>						

Required	{	P Z M the Sun's <i>Azimuth</i> .
		Z P M the Hour of the Day.
		Z M P the Sun's <i>Angle</i> of <i>Position</i> .

To represent this *Triangle* on the
GLOBE.

Elevate the *Pole* to the *Latitude*, then count Z P 38 deg. 30 min. the Complement of the *Latitude* from the *Pole* on the *South* Side of the brazen *Meridian*, and where the Reckoning ends, skrew the *Quadrant* of *Altitude*; this done, count the Side M P 70 deg. upon the *Equinoctial Colure* from the *Pole*, and the Side Z M upon the *Quadrant* of *Altitude* from the *Zenith* downwards, and so move the *Globe* and *Quadrant* of *Altitude* together, till the Numbers counted on the *Colure* and *Quadrant* of *Altitude* meet in one Point, so will the *Triangle* be exactly delineated upon the *Globe*.

Now to find the several Angles.

For the Angle at Z, count the Number of Degrees of the *Horizon*, which are contained between the *North* Point of the *Meridian* and the *Quadrant* of *Altitude*, which you will find to be 115 deg. 35 min. the Sun's *Azimuth* from the *North*.

For the Angle Z P M, number the Degrees of the *Equator* contained between
the

the *South* Part of the brazen *Meridian* and the *Colure*, which you will find to be 45 deg. which reduced to Time is 3 Hours, the Hour from *Noon*; namely, 9 in the *Morning*, or 3 in the *Afternoon*.

For the Angle Z M P, the Angle of the Sun or Stars Position at the Time of the Question; count 42 deg. 48 min. the Complement of M Z, upon the *Quadrant* of *Altitude* (it being brought to the other Side of the *Meridian*) and also count 20° the Complement of M P on the *Colure* (on the other Side of the *Meridian*) the Distance of these two Points measured with a Pair of *Compasses* or otherwise, gives 36 deg. 52 min. which is the Angle of the Sun's Position.

So that by the Knowledge of the *Latitude* of the Place of *Observation*, the *Altitude* and *Declination* of the Sun or Star, the exact *Hour* of the *Day* or *Night* may be known, and the *Azimuth* of the *Celestial Phenomenon*.

Also by having any three Parts of the *Triangle* given, the other three may be found; which affords a great many *Varieties* or *Cases*, in every *Oblique Angled Spherical Triangle*.

This *Oblique Angled Spherical Triangle* may also be applied to *Geographical* or *Nautical Questions*; for

The Side ZP may represent the Complement of the *Latitude* of that City, whose *Zenith* Point is Z .

The Side PM will be the Complement of that City or Town at M .

The Side ZM may represent the Distance between those two Cities.

The Angles PZM is the Difference of Longitude between the two Cities M and Z .

The Angle MPZ , the Point of the Compass leading from Z to M .

The Angle PMZ , the Point of the Compass leading from M to Z .

From which it's evident that the *Bearing* or *Course* from Z to M , the Reverse of that *Course* will not carry from M to Z , which makes good the *Geographical Paradox*, that a Place may lie *East* of *London*, and *London* not lie *West* of that Place.

Moreover, in the same *Triangle* you may make the Side ZP , the Distance of the *Pole* of the *Equator* from the *Pole* of the *Ecliptick*: Then PM will be the Complement

Complement of the *Declination* of a Star at M; the Side Z M will be the Northern *Latitude* of that Star; the Angle M P Z will be the Complement of the Star's *Right Ascension*, the Angle P Z M, the Quantity of the Star's *Longitude*, and the Angle P M Z, the Angle of the Star's Position.

There are divers other Triangles both Right and Oblique Angled; but these, as the most particular, I recommend to the Practice of the *Learner*, which, if well understood, will enable him to proceed to a further Use of the *Globes*, as applied to *Gnomonical Problems*.



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There are divers other Triangles both Right and Oblique Angled; but these, as the most particular, I recommend to the Practice of the *Learner*, which, if well understood, will enable him to proceed to a further Use of the *Globes*, as applied to *Gnomonical Problems*.



S E C T. XIII.

*Of the Practical Use of the
GLOBES in the Solution of
Gnomonical Problems.*

AMong the *various* pleasing and profitable Amusements which arise from the Use of the *Globes*, that of *Dialling* is not the least, because it rewardeth those that incline to exercise themselves that Way, with Abundance of Pleasure, and is of universal Use to Mankind in determining the *Periods* of Time allotted for *Business, Company* or *Retirement*, &c.

The *Ancients* being sensible of this *Advantage*, invented several Ways, whereby they might distinguish and observe the *Hours* either by *Day* or *Night*, but none with less *Charge* or greater Certainty answered their Design, than Sun-Dials drawn upon the Superficies of fixed *Bodies*. And the whole *Art* of *Dialling* being most naturally and clearly *illustrated* by the Help of *Spheres* or *Globes*: We shall

shall in this Section consider those *Kinds* of *Dials* only, which may easily be constructed by the *Globes*, and drawn upon plain *Superficies*, which being thoroughly understood as a Foundation, any Person acquainted with *Arithmetick* and *Geometry*, will easily conceive how all other *Kinds* of *Dials* may be drawn, whether by *Lines* or *Numbers*.

1. Every *Dial-Plane* (*i. e.* Plain Surface on which a *Dial* is drawn) represents the Plane of some great *Circle*, which *Circle* is an *Horizon* to some Country or other. The *Center* of the *Dial* representeth the *Center* of the Earth, and the *Gnomon* which casteth the Shade, representeth the *Axis*, and ought to point *directly* to the *Poles* of the *Equator*.

2. All *Plains* upon which *Dials* are made in any *Latitude*, do either lie; 1st, *Parallel* to the *Horizon*: or, 2^{dly}, are perpendicular to the *Horizon*: or, 3^{dly}, do cut the *Horizon* at *Oblique* Angles.

3. A Plain that lieth parallel to the *Horizon*, is said to be an *Horizontal* or *Vertical* Plain.

4. Of

4. Of Plains that are perpendicular to the *Horizon*, there are two *Varieties* : for,

First, If they are parallel to the *East* and *West Azimuth*, and so stand directly *North* and *South*, or *parallel* to the *Meridian*, and behold the *East* and *West*, such are called *Direct Vertical Plains*.

Secondly, If they stand in any other *Azimuth*, and are *perpendiculars* to the *Horizon*, then they are called *Vertical Plains*, declining from the *North* or *South*.

5. Of *Plains* that cut the *Horizon* at *oblique* Angles, there are several *Varieties*, as shall be shewn, when we come to consider *inclining* and *reclining Dials*.

P R O B. I.

To make an Horizontal Dial.

The Operation by the G L O B E.

Elevate the *Pole* to the *Latitude* of the *Place* for which you would make your *Dial* (suppose to *London*, in the *Latitude* of $51^{\circ} 30'$) and bring the *Vernal Colure* to the *Meridian*, and the *Hour Index* to *12* on the *Hour Circle*,

And

And turn- ing the Globe W. wards, till the Index point to	1	a Clock, or till 15° of the Equator pass through the Meridian, and the Colure will cut the Horizon in	110	50'	From the Me- ridian.
	2		24	20	
	3		38	03	
	4		53	36	
	5		71	06	
	6		90	00	

These are the *Distances* of the *Hour-Lines* from *Noon* till *six* at *Night*, and the same *Distances* serves for the *Hours* betwixt 6 in the *Morning* and 12 at *Noon*, for the one a *Clock Hour-Line* in the *Afternoon* is equidistant from the *Meridian*, or *Noon-Line*, with the 11 a *Clock Hour-Line* before *Noon*, and so all the other *Morning Hour-Lines* are distant from the *Noon-Line* by the same *Space* that the same *Number* after *Noon-Hour-Lines* (numbred from the *Meridian* on the contrary *Side* of the *Noon-Line*) are distant from the *Meridian*.

If you would have the half *Hour-Lines* plac'd on your *Dial*, you must turn the *Globe* till the *Index* points to every half *Hour* on the *Hour-Circle*, and mark the *Degrees* of the *Horizon*, cut by the *Vernal Colure*, for those are the *Degrees* belonging to the half *Hours* required.

The Geometrical Construction of this
D I A L.

1. Upon the Plain on which you design to draw your *Dial* (as in Plate 11. Fig. 3.) draw a right Line A B, representing the *Meridian* of your *Globe*, and the Hour-Line of 12.

2. Towards one End of this Line, assign a Point C, representing the Center of your Dial, and through that Point draw another Line at *Right Angles* to A B, which shall be the Hour-Line at 6, as the Line K M; and upon the Point C, with the *Radius* of some Line of *Chords*, describe a Semicircle D E F.

3. Then seeing 11 and 1 a Clock are distant from the *Meridian* 11 deg. 50 min. take 11 deg. 50 min. from your Line of *Chords*, and set it upon the Semicircle from E to 11, and from E to 1, and draw the Lines C 11, and C 1, for the Hour-Lines between 11 and 1.

4. The

4. The Distance of 10 and 2, being 24 deg. 20 min. take from your Line of *Chords* 24 deg. 20 min. and set it from E to 10, and from E to 2, and draw the Hour Lines of 10 and 2, do thus with the rest of the Hour-Lines, till 6 in the *Morning* and 6 at *Night*; and for the Hour-Lines of 4 and 5 in the *Morning* and of 7 and 8 at *Night*, continue the Hour-Lines of 4 and 5 in the *Afternoon* through the Center to the other Side of the *Dial*, and they will be the Hour-Lines of 4 and 5 in the *Morning*; and the Hour-Lines of 7 and 8 in the *Forenoon* continued, will be the Hour-Lines of 7 and 8 in the *Afternoon*.

5. For the Style or Cock of your *Dial* take 51 deg. 30 min. the Latitude from your Line of *Chords*, and set that Distance upon the *Semicircle* from E to G, and draw the Line C G for the Style, which must stand upon the Line of 12, without inclining to the *East* or *West*, and so is your *Dial* finished.

P R O B. II.

To make an Erect South Dial for Latitude 51 deg. 30 Min.

The Operation by the *Globe*.

You may reduce all *Verticals* to *Horizontals*, if you elevate the *Pole* to the Complement of the Latitude, which in this Case is 38 deg. 30 min. and bring the *Vernal Colure* to the *Meridian*, and the *Index* to 12, then turn the *Globe Westwards*, and as each 15th Degree is at the *Meridian* (or as the *Index* points out the several Hours on the Hour-Circle) the *Colure* shews in the *Horizon* the Distance of the several Hour-Lines, from the *Meridian* as in the following Table.

Compt. Latitude 38° 30'.			
Hours.		Distances from the Meridian.	
12		00°	00'
11	1	09	28
10	2	19	45
9	3	31	54
8	4	47	09
7	5	66	42
6		90	00

The

*The Geometrical Construction, Plate 11,
Fig. 2.*

1. Draw a *Meridian-Line*, as L M, for the Hour-Line of 12, *cross* it at *Right Angles* with the Line N P for the Hour-Line of 6, and 6, and where these Lines *cross* each other (as at O) is the Center of the *Dial*.

2. With the *Chord* of 60 deg. draw a Semicircle N P Q, and from the Line of *Chords* take the Hour Distances (as in the above Table) from the *Meridian*, and lay on the Semicircle one Foot of the Compass being in the *Meridian*; thro' which Distances, from the Center, draw the Hour-Lines as in Prob. 1.

3. For the Style, take 38 deg. 30 min. (the Complement of that *Latitude*) from the Line of *Chords*, set it from Q to R, and draw the Line O R for the Cock or Style of your *Dial*, which must stand over 12, and point downwards towards the *South Pole*.

N. B.

N. B. The *North Vertical Dial* is the same with the *South*, only the *Style* must point upwards, toward the *North Pole*, and the Hours 9, 10, 11, 12 at Night, and 1, 2, 3 in the Morning must be left out, and 4, 5 in the Morning and 7, 8 at Night, must be drawn through the *Center*, so is your *North Dial* finished.

P R O B. III.

To make an Erect, Direct East or West Dial.

These Sorts of *Dials* may be better demonstrated than made by the *Globe*, for the *Pole* being rectified to the *Latitude*, the *Index* to 12, and the *Quadrant* of *Altitude* in the *Zenith*: If the *Quadrant* be brought about till the graduated *Edge* thereof be exactly *East* or *West*, and turning the *Globe* about, the *Equinoctial Colure* will not cut the *Quadrant* of *Altitude* in any particular Degree, but a Part of the *Colure* will coincide with all the Degrees of the *Quadrant* at the same time; wherefore the *Hour-Lines* of these *Plains* will make no Angles at the *Pole*, and consequently must be parallel to one another, which

which the *Globe* plainly represents, but will not conveniently give the *Parallel Distance* of each from the other, they being nearer or farther off, according as the *Style* is proportioned to the *Plain*.

The Geometrical Construction.

Let the *Plain* upon which you would make an *East* or *West Dial* be ABCD. Plate 11. Fig. 3.

1. Upon D, if it be an *East Dial Plain*; or upon the Point C, if it be a *West Dial*, with the Radius of your Line of *Chords*, describe an *Arch* of a Circle G F, then from your Line of *Chords* take 38 deg. 30 min. and draw the Line DGE quite through the *Plain* for the *Equinoctial* towards the upper Part of this Line, as at P, assume any Point, and through it draw the Line 6 P 6, perpendicular to the *Equinoctial* for the Hour-Line of six, also towards the lower Part of the same Line, assume another Point as L, and through it draw the Line 11 C 11, for the Hour of eleven.

2. With 60 deg. from your *Chords*, upon the Point C, describe a small *Arch* of

a Circle as H K, and upon it set 15 Degrees, or one Hour's Distance from H to K, and draw the Line C K M, cutting the Hour-Line of 6 in M.

Upon M as a Center, with 60 deg. from your Chords, describe an Arch of a Circle N O, which divide into five equal Parts in the Points O, O, O, &c. Lay a Ruler upon M, and each of these Points, and the Ruler will cut the *Equinoctial Line* D E in the *Points* *** through which *Points*, if you draw right *Lines* parallel to the Hour-Line of 6, they will be the Hour-Lines of 7, 8, 9 and 10, the Hour-Lines of 6 and 11 being drawn before.

For the Hour-Lines of 4 and 5 in the Morning, they retain the same Distance from six, as do the Hours 8 and 7.

The *Style* must stand upon the Hour-Line of 6, and be in Height equal to the Length of the Line M P, and may be either a Pin or Wyre, or a Plate of *Brass*, or *Iron*.

An Erect, Direct West Dial is the same in all Respects with an Erect, Direct East Dial, only as the East shews the Forenoon Hours, the West shews the Afternoon,
Hours

Hours, for that which in the East-Dial is 10, the West-Dial must be 2; and 9 in the East-Dial, must be 3 in the West.

P R O B. IV.

Of erect Declining Plains.

The upright or erect Plains that we have hitherto treated of, are such as do directly behold the four *Cardinal Points* of the Horizon, all other upright Plains are said to decline, and their Declination is counted from the North or South, towards the East or West; thus to make an *erect Dial* for 51 deg. 30 min. N. the Plain declining from the North towards the East, 63 degrees. Elevate the Pole to the given Latitude, fix the Quadrant of Altitude to the Zenith, and number the Declination of the Plain upon the Horizon from the North (or South Point thereof according as the Plain declines) namely, 63 deg. and to that Point of the Horizon bring the Quadrant of Altitude, and there fix it, then bring the Vernal Colure to the Meridian, and the Index of the Hour Circle to the uppermost Figure of 12, in the Hour Circle then turn the Globe Eastwards, till the

Z

Index

Index points to all the Hours before Noon; and examine in what Number of Degrees from the Zenith the Colure cuts the Quadrant of Altitude, when the Index points to each Hour, or when each 15 Degrees of the Equator passes the Meridian, for the Degrees of the Quadrant, numbred from the Zenith cut off by the Colure, are the Distances of the Forenoon Hour-Lines, as are exprest in the following Table.

Hours from Noon.	Hours dist. on the Plain.
	0
11	9 43
10	19 00
9	25 57
8	35 10
7	45 56
6	60 15
5	79 45

There is this Difference between *direct* and *declining Dials*, that the the Hour-distances for the Afternoon on *declining Dials*, are not the same with the Hour-distances for the Forenoon, because the Sun remains longer on that Side of the Plain which it declines to, than it doth on the contrary Side, therefore there will be a greater Number of Hour Lines upon it, and by consequence the Distances of the Hour-Lines less than on the contrary Side of the Plain;

Plain; therefore for finding the Afternoon Hour Distances, turn about the Quadrant of Altitude upon the Zenith Point, till the lower End of it comes to the Degree of the Horizon, opposite to that Degree of Declination, the Quadrant of Altitude was placed at when the Distance of the Forenoon Hour-Lines was found, *viz.* to 63 Degrees counted from the South, towards the West, and bring the Vernal Colure again to the Meridian, and the Index to 12, then turning the Globe Westwards, as the Index points to the several Hours, or at each 15 Degrees of the Equator passing the Meridian, the Colure will cut the Quadrant of Altitude in the Afternoon Hour-Distances numbred from the Zenith, as are expressed in the following Table:

Z 2

It's

Hours from No. n.	Hour- Distances upon the Plain.
1	11 20
2	26 47
3	49 20
4	75 52

It's to be observed that this Plain is capable of receiving no more Hour-Lines after Noon than 4; for when the Colure goes off the Quadrant of Altitude, the Sun goes off these Kind of Plains.

And to find the Distance of the *Substilar-Line* from the 12 a-Clock Line, and the Elevation of the Style about the Plain, which are two Requisites always to be found in upright declining Plains, bring the Colure to the Number of Degrees of the Plain's Declination counted in the *Horizon*, from the South Point towards the East, and the Quadrant of Altitude to the Degrees of the Plain's Declination on the *Horizon* from the North towards the East, so shall the Quadrant of Altitude and the Colure cut each other at right Angles, and the Number of Degrees comprehended between the Colure and Zenith in the Quadrant of Altitude, shall be the Number of Degrees between the *Substilar-Line* and the 12 a-Clock-Line, which in this Example is 19 deg. 45 min. and the

the Number of Degrees comprehended between the *Quadrant* of *Altitude* and the *Pole*, counted on the Colure, shall be the Number of Degrees that the Style is to be *elevated* above the Plain, which in this Example is 33 deg. 40 min.

The Geometrical Construction
as in Plate 11. Fig. 4.

Draw on your *Plain* an *Horizontal* Line as C D, and with the Chord of 60 Degrees describe a Semicircle D B C, which divide into two equal Parts, and draw the Line A B, which will be the Hour of 12, then from a Line of Chords take the several Hour Distances from the Meridian, and lay on the Semicircle from B to C and D, drawing Lines from the Center A, through those Divisions, so shall all the Hour-Lines be represented on the Plain; then to represent the *Substilar-Line* on that Plain, from the Line of Chords take 19 Degrees 45 Minutes the Distance of the *Substilar Line* from the 12 a Clock Line) and on the Semicircle from the 12 a Clock Line at B, set it off to x, on the contrary Side
to

to the Declination of the Plain, which in this Case must be in the West side, and from the Center A draw A x, which shall represent the *Substilar-Line*; and from the *Substilar Line* lay off 33 deg. 40 min. (the Elevation of the Style above the Plain) on the Circle from x to y, then draw the Line A y for the Style or *Gnomon*, and let fall the Perpendicular a b upon the *Substile*, so you have a *Triangle*, which erected perpendicular upon the *Substile* A x, the Style A y shall be parallel to the *Axis* of the World, and cast a Shadow upon the Hour of the Day.

Here you may observe that in *declining Dials*, the Stile doth not stand at the same Elevation above the Plain that it doth in *erect direct Dials*, neither doth it stand over the 12 a-Clock Line, but on some Part of that Quarter towards which the Declination of the Plain is.

Thus you have finish'd your Dial, and in so doing, you have in this one made four Dials, *viz.*

A	{	North declining East	}	Deg. Min.
		North declining West		63 00
		South declining East		
		South declining West		

Only placing the Number of the Hours and the Style respectively upon each Plain. For in the *South-West* Plain, the Stile stands upon the Hours of 2 in the Afternoon; in the *South-East*, declining as much, it will stand upon the Hour-Line of 10 before Noon. And so all the Morning Hours of the West-Decliner will be the Afternoon Hours of the East-Decliner, and the Afternoon-Hours of the West-Decliner will be the Morning-Hours of the East-Decliner; and the South-East Decliner will produce the North-West Decliner, and the South West Decliner, the N. East Decliner, by only extending the Hour-Lines, Stile and Substile, quite thro' the Center.

P R O B. IV.

Of Direct South Reclining DIALS.

Reclining Plains are those that cut the *Horizon* at Oblique Angles, *reclining* from the *Zenith*, or *inclining* to the *Horizon*, and are either *direct North*, *South*, *East*, or *West reclining*, or *declining* from the

North, West, &c. and so are call'd *declining inclining Plains*.

A South Plain may so recline that the Reclination thereof may be either,

Less than	} the Complement of the <i>Lat.</i>
Equal to	
More than	

Now to reduce any of these Plains to a new *Latitude*, where they may become *Horizontal Plains*.

1. If the *Reclination* of the Plain be less than the Complement of the known *Latitude*, subtract the Plain's *Reclination* from the Complement of the *Latitude*, and the Remainder shall be a new *Latitude*, where the *Reclining Plain* shall be an *Horizontal Plain*, and in this Case the *South Pole* (in *North Latitude*) is always elevated.

2. If the *Reclination* be equal to the Complement of the *Latitude*: In that Case the *Plain* lies in the *Axis* of the *World*, and hath the *North Pole* elevated above it.

3. If

3. If the *Reclination* of the Plain be more than the Complement of the *Latitude*, subtract the Complement of the *Latitude* from the Plain's *Reclination*, and the Remainder shall be the new *Latitude*; and in this Case the *North Pole* in *North Latitudes* is always *elevated*.

In the first of these three *Varieties*: If a *South Plain* in the Latitude of 51 deg. 30 min. recline 20 min. which is less than the Complement of the given Latitude; therefore the *Reclination* being subtracted from it, leaves 18 deg. 30 min. for the new Latitude: Wherefore if you *rectifie* the Globe to 18 deg. 30 min. of Latitude, and find the Distances of the Hour-lines from the *Meridian*, for a *Horizontal Dial* in that Latitude by *Prob. 1.* that Dial shall serve for a South Reclining 20 deg. in the Latitude of 51 deg. 30 min. and the *Height* of the *Stile* above the 12 Hour-Line (or Substile) will be equal to the new Latitude, namely 18 Degrees 30 Minutes.

In the *second Case*, when the *South Reclination* and Complement of the *North Latitude* are equal, the *Dial* is to be made in all Respects like an *East* or *West Dial*;

A a

only

North, West, &c. and so are call'd *declining inclining* Plains.

A South Plain may so recline that the Reclination thereof may be either,

Less than	}	the Complement of the <i>Lat.</i>
Equal to		
More than		

Now to reduce any of these Plains to a new *Latitude*, where they may become *Horizontal Plains*.

1. If the *Reclination* of the Plain be less than the Complement of the known *Latitude*, subtract the Plain's *Reclination* from the Complement of the *Latitude*, and the Remainder shall be a new *Latitude*, where the *Reclining Plain* shall be an *Horizontal Plain*, and in this Case the *South Pole* (in *North Latitude*) is always elevated.

2. If the *Reclination* be equal to the Complement of the *Latitude*: In that Case the *Plain* lies in the *Axis* of the *World*, and hath the *North Pole* elevated above it.

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3. If the *Reclination* of the Plain be more than the Complement of the *Latitude*, subtract the Complement of the *Latitude* from the Plain's *Reclination*, and the Remainder shall be the new *Latitude*; and in this Case the *North Pole* in *North Latitudes* is always *elevated*.

In the first of these three *Varieties*: If a *South Plain* in the Latitude of 51 deg. 30 min. recline 20 min. which is less than the Complement of the given Latitude; therefore the *Reclination* being subtracted from it, leaves 18 deg. 30 min. for the new Latitude: Wherefore if you *rectifie* the Globe to 18 deg. 30 min. of Latitude, and find the Distances of the Hour-lines from the *Meridian*, for a *Horizontal Dial* in that Latitude by *Prob. 1.* that Dial shall serve for a South Reclining 20 deg. in the Latitude of 51 deg. 30 min. and the *Height* of the *Stile* above the 12 Hour-Line (or Substile) will be equal to the new Latitude, namely 18 Degrees 30 Minutes.

In the *second Case*, when the *South Reclination* and Complement of the *North Latitude* are equal, the *Dial* is to be made in all Respects like an *East or West Dial*;

A a

only

only, that which in the *East* or *West Dial* is the fix a-Clock Hour-line, must in these *Dials* be the Hour-line of 12, &c.

In the *third Case*, suppose a South Plain to recline from the *Zenith* 60 deg. in the *Latitude* of 51 deg. 30 min. the Complement of which subtracted from 60 deg. leaves 21 deg. 30 min. for the new *Latitude*, and by *Prob. 1.* find the Hour-distances for the *Horizontal Dial* in that *Latitude*, which Hour-distances will serve for a South-Dial reclining from the *Zenith* 60 degrees in the *Latitude* of 51 deg. 30 min. and the Stile of the Dial must be elevated above the Substile (or Hour-line of 12) 21 deg. 30 min. equal to the Complement of the *Latitude*, and point upwards towards the *North Pole* as the Stiles of all South-Plains do, which recline more than the Complement of the *Latitude*, thus the Hour-distance of all *South* reclining *Dials*, may be found by the *Globe*, by referring such reclining Plains to a *Latitude*, where they may become *Horizontal Plains*.

P R O B.

P R O B. V.
Of *North reclining* DIALS.

There are three *Varieties* of *North Decliners*, as there are of *South Recliners*, for the Reclination may be either,

Less than	}	the <i>Latitude</i> of the Place.
Equal to,		
More than		

And to refer these to a new *Latitude*, where they will be *Horizontal Plains*, you must observe,

1. If the Reclination of the *Plain* be less than the *Latitude*, add the Complement of the *Latitude* to the Plain's Reclination, and the Sum will be the *new Latitude*: Thus, Let a North Plain in the Latitude of 51 deg. 30 min. recline from the Zenith 20 deg. add 20 Degrees the Plain's Reclination to 38 deg. 30 min. (the Complement of the Latitude) the Sum will be 58 deg. 30 min. which is the new Latitude. Wherefore, if you rectifie the Globe to 58 deg. 30 min. and by *Prob. 1.* find the Hour-distances of a *Horizontal Dial* in that Latitude, that Distances will serve for

a North Plain reclining 20 deg. in the Latitude of 51 deg. 30 Min. *North*, and the *Stile* must be elevated above the *Substile* (or *Hour-line* of 12) 20 deg. equal to the new Latitude.

In the second of these *Varieties*, where the Plain of the Meridian reclines, so as to cut the Meridian, just at the Intersection of the *Meridian* with the *Equator*, the Plain itself lying in the *Equinoctial Circle*, and the *Poles* thereof in the Poles of the World; it is call'd a *Polar Plain*. Wherefore rectify the Globe to 90 deg. of Lat. so shall the *Poles* be in the *Zenith* and *Nadir*, and the *Equator* in the *Horizon*, then turn the Globe about till 15 Degrees of the *Equinoctial Colure* have pass'd the *Meridian*, and it will rest at 15 deg. of the *Horizon*, which is the first Hour's Distance from 12, and in these Plains the Degrees of the *Equator* and *Horizon* being the same, the Hour-lines are equally removed from one another; wherefore, if a Circle be described and divided into 24 equal Parts, *Lines* being drawn from the Center to each Division, and a *Wyre* perpendicularly placed in the Center, the Dial is finished. In

In the *third Case*, when the *Plain* reclines more than the Latitude, and cuts the Meridian between the *Equator* and the *Horizon*; add the Reclination to the Complement of the Latitude, which Sum (if it don't exceed 90 deg.) is a new Latitude, but if it exceeds 90 deg. subtract that Sum from 180 deg. and the Remainder will be a new Latitude, for which new Latitude rectify the Globe, and make an *Horizontal Dial* by *Prob. 1.* elevate the *Stile* above the 12 a Clock Hour-line equal to the new Latitude, and the *Dial* is finished.

PROB. VI.

*Of Declining, Reclining, or Inclining
PLAINS.*

Such *Plains* as do not behold the *East West, North, or South* Points of the *Horizon* directly, are called *Decliners*, and if they are not perpendicular to the *Horizon*, they both decline and incline, therefore they are called *Declining Inclining Plains*; for the making of these
kind

kind of *Dials*, let us suppose a *Plain* in the *Latitude* of 51 deg. 30 min. to decline from the *North Part* of the *Meridian* towards the West 72 degrees, and also to recline from the *Zenith* $26^{\circ} 34'$.

1. Elevate your *Globe* to the given *Latitude* 51 deg. 30 min. fix the *Quadrant of Altitude* in the *Zenith*, the *Hour-Index* to 12 and the *Equinoctial Colure* to the *Meridian*.

2. The *Declination* of the *Plain* being 72 deg. *Westward*, count upon the *Horizon* 20 deg. (the Complement of the *Declination*) from the *South Part* of the *Meridian Westward*, and from the *North Part* of the *Meridian Eastward*, and to these two Points on the *Horizon* bring the Ends of a narrow Plate of thin Brass (containing a compleat *Semicircle*) divided into Degrees, beginning the *Divisions* at the middle, and numbering them both Ways and there fix it, then bring the *Quadrant of Altitude* to 20 Degrees on the *Horizon*, counted from the *East Southward*. Now because the *Plain* reclines 26 deg. 34 min. count those Degrees downwards from

from the *Zenith*, and to that Point bring the thin Plate of Brass representing your *Plain*, and there fix it, so is your *Globe* prepared for the making of your *Dial*, and for the Hour-distances, turn the *Globe Eastward*, till 15 Degrees of the *Equator* have pass'd the *Meridian*, and upon the *Plain* (or *Plate* of Brass) you will find the *Colure* cut the *Semicircle* counted from the Middle of it at 26 deg. 3 min. and by turning still *Eastward*, and observing where the *Colure* cuts the *Semicircle* at each 15 Degrees of the *Equator*, passing the *Meridian*, you will find the Forenoon Hour-distances, as in the following Table ; and the *Colure* being again brought to the *Meridian*, and the *Globe* turned to the *West*, at each 15 Degrees of the *Equator*, crossing the *Meridian*, the *Colure* will cut the *Semicircle* in the Afternoon Hour-distances, as in the following Table :

Hours

Hours,		°	'
Forenoon	12	00	00
	1 11	26	3
	2 10	44	30
	3 9	57	47
	4 8	67	53
Afternoon	5 7	76	12
	Substile	Substile	
	6 6	84	15
	7 5	87	38
	8 4	78	25
	9 3	66	48
	10 2	50	46
	11 1	28	4

Now besides these Hour-distances, you must find four Things more, preparatory to the *Geometrical Construction* of these *Dials*.

1. *The Arch of the Plain (or the Distance) between the Meridian and Horizon*, which may be found thus :

Take with your *Compasses* the *Distance* upon the *Plain*, from the *Intersection* of the *Plain* with the *Horizon*, to the *Intersection* of the *Plain* with the *Meridian*, which Number of Degrees, namely, 36, is the *Distance* required.

2. *The*

2. *The Arch of the Meridian between the Plain and Zenith thus:* The Degrees of the *Meridian* intercepted between the *Plain* and *Zenith*, viz, 58 deg. is the *Arch* required.

3. *The Height of the Pole and Stile above the Plain.*

To find which, continue your *Quadrant* of *Altitude* from the *Zenith* below the *Horizon*, so much as is the *Reclination* of the *Plain* 26 deg. 34 min. and mark that Point. Then a thin *Plate* of *Brass* (if the *Quadrant* of *Altitude* be too short) divided, and extended from the *North Pole* towards the *South Pole*, and passing through the *Pole* of the *Plain* (which is the Point before found) mark where the *Plate* cutteth the *Plain*, and the *Number* of *Degrees* upon the *Plate* contain'd between the *Pole* and the *Plain* which in this *Case* will be 31 deg. 28 min. is the *Height* of the *Pole* above the *Plain*, or *Substile*.

4. *The Distance of the Substile from the Meridian.*

B b

And

And that is, the Number of *Degrees* of the *Plate* representing the *Plain*, which are contain'd between the *Plate* which came from the *Pole* of the *World* to the *Pole* of the *Plain*, and the *Intersection* of the *Plain* with the *Meridian*, which in this *Example* will be 82 deg. 4 min. as appears by the following Table.

North Declining - - -	72° 00'
Reclining - - - - -	26 34
Distance between the Meridian and Horizon	} 36 00
Distance between the Plain and Zenith	} 58 36
Height of the Pole above the Plain	} 31 28
Distance of the Substile and Meridian	} 82 4

The Geometrical Construction of this
D I A L. Fig. 5. Plate 11.

1. Upon the *Plain*, upon which you intend to describe your *Dial*, draw a *Horizontal-Line* thereupon as A B, and another

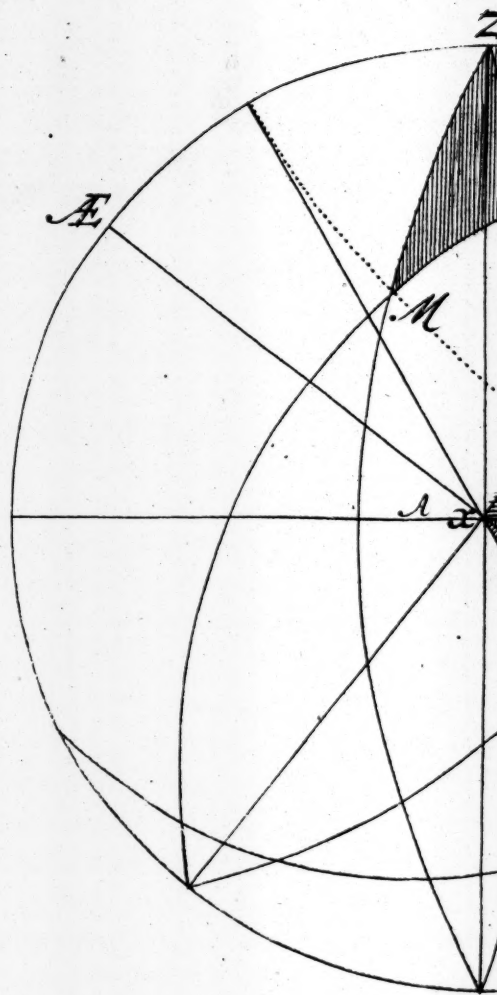


Plate 10.

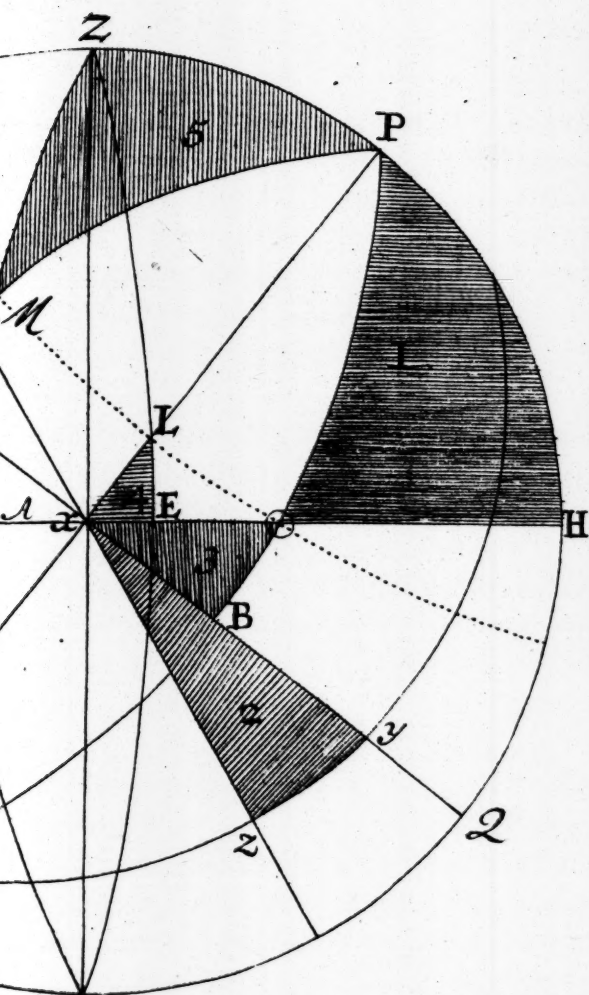
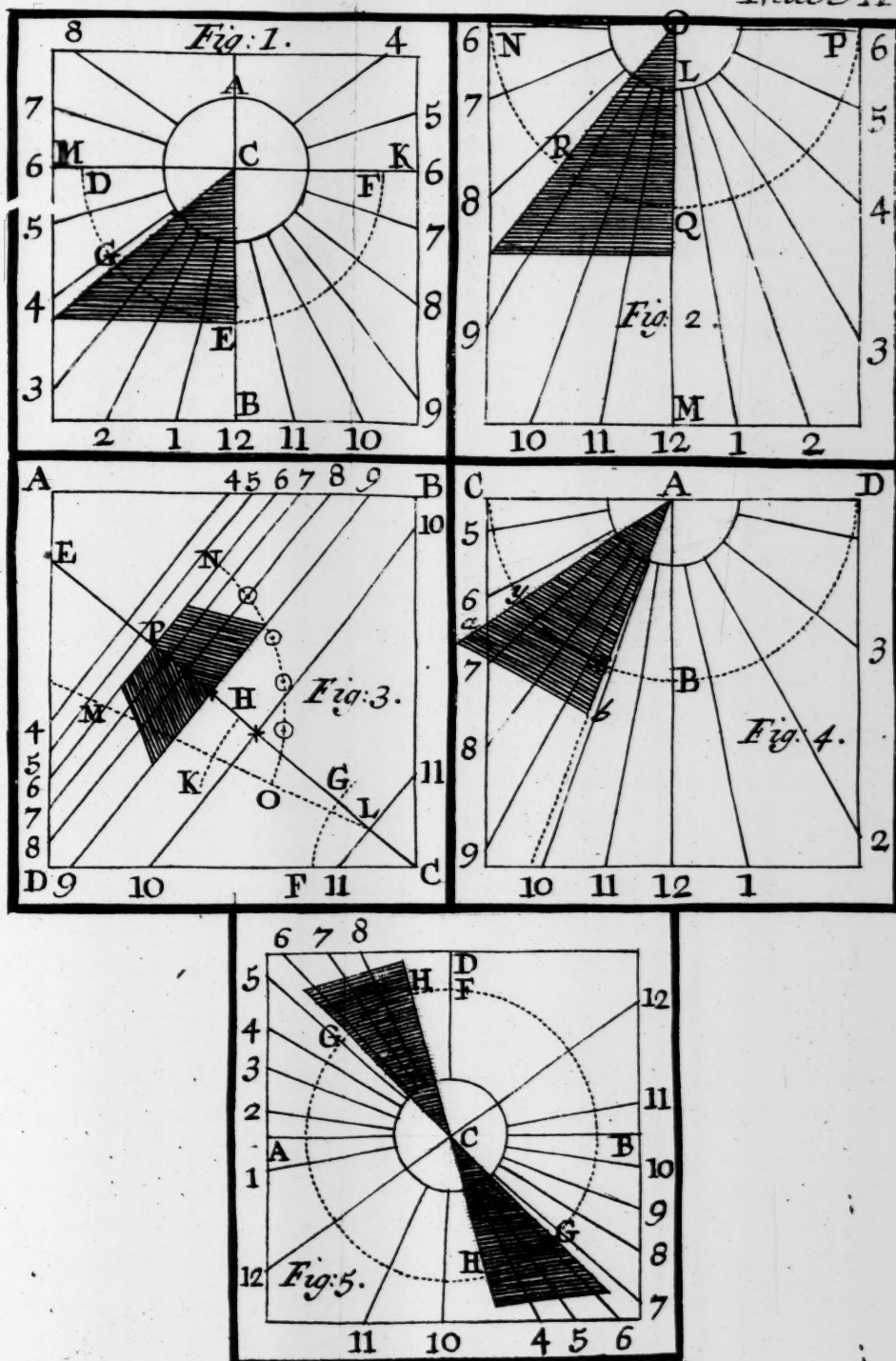


Plate 11.



another perpendicular to it as D G, for the *Vertical-Line* of your *Plain*, cutting the former A B in the Point C, which Point C makes the *Center* of your *Dial*.

2. Upon the *Center* C, with 60 deg. of a *Line of Chords*, describe a *Circle*, as A F B G, then take 36 deg. (*the Distance of the Meridian from the Horizon*) and set it from A to 12 downwards, and from B to 12 upwards, and draw the *Line* 12 C 12, for the *Hour-Line* of 12.

3. Take 82 deg. 4. min (*the Distance of the Substile from the Meridian*) and set them from 12 upwards to G on the left Hand, and downwards from 12 to G on the right Hand, drawing the *Line* G C G, through the *Center*, for the *Subsilar-line* of both *Dials*: And the *Height of the Pole or Stile* above the *Plain*, being 31 deg. 28 min. set those Degrees from G to H, both above and below, and draw the *Line* H C H quite thro the *Center* for the *Axis* or *Stiles* of both *Dials*.

4. Laying your *Table of Hour-distances* before you, and there finding the first *Hour's Distance* from 12 is 26 deg. 3 min. Set that Distance upon the *Circle* from 12 upwards to 1, and from 12 (on the

the other Side) downwards to 11, and draw the Lines G 1, and C 11; for the *Hour-lines* of 11 and 1 a *Clock*, which will both make one strait Line.

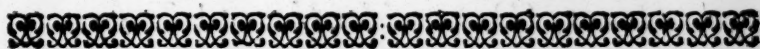
Do thus with all the Hours in the *Table*, till you come upon the *Substile*, and then (beginning at the Bottom of the Table)

5. Take 28 deg. 4 min. and set from 12 on the right Hand downwards to 11, and from 12 on the left Hand upwards to one, draw the Line C 11 in the *North* reclining *Plain*, for the Sun will never shine upon the *South reclining Plain*, at 1, otherways you should have drawn it thro the *Center* as you did before.

Lastly, Erect your *Stile* perpendicular to your *Substile*, making an *Angle* therewith equal to the *Elevation* thereof; namely, 31 deg. 28 min. and your *Dials* are finished. And in making of these you have made two others also, *viz.* A *North Declining* 72 deg. *Eastward*, and *Inclining* 26 deg. 34 min. and a *South Declining Westward* 72 deg. and *inclining* as the other; all which is done (and may easily be apprehended by any Person as is discovered in the 4th *Problem* of this Book for *Upright Declining Plains*.



A
C O M P E N D
O F
C H R O N O L O G Y.



S E C T. I.

*Of the several Parts of Time,
as divided into Hours, Days
and Months.*

CHRONOLOGY is that Science
which treats of Time, or the A-
rithmetical Computation of Time
for Historical Uses, so as thereby truly to
date the beginning and ending of Princes
Reigns ;

Reigns; the *Revolutions* of *Empires* and *Kingdoms*, *Battles*, *Sieges*, or any other memorable *Action*. It is divided into two Parts, *viz.* *General* and *Special*.

The *General* Part is that which considers Time in *general*, with its divers *Denominations* and *Characters*.

The *Special* Part is that which considers Time in particular, by *demonstrating* the Certainty of Epochas, and taking a *View* of the *Calendars* or *Fasti* of divers *Nations*.

The most considerable *Parts* of *Time*, are, *Hours*, *Days*, *Months* and *Years*.

A Day is a Space of *Time* wherein the *Sun* by his apparent *Motion*, either describes a certain Part of a *Circle*, or makes an entire *Revolution*, and is either *Natural* or *Artificial*.

A Natural Day is the Duration of an entire apparent Revolution of the Sun about the Earth.

The Artificial is that Part of the Natural Day, in which the Sun *continues* above the *Horizon*, and is opposite to the *Night*, being that Part of *Time* which the Sun is
under

under the *Horizon*; but the Natural Day contains both.

The Natural Day is either *Astronomical* or *Civil*; the *Astronomical* Day is the Space of Time that *flows* between the Sun's leaving a *given Meridian* and the next Return to the same; that is, the Space of Time wherein a Revolution of the whole *Celestial Equator* is performed, and of that Part of it *besides* which answers to 59 Minutes, 8 Seconds of the *Ecliptick*, the Sun's Mean Motion in one Day; for when the Degree of the *Equator* the Sun was in, when last at the *Meridian*, together with the Degree of the *Ecliptick* opposite to it, are again *arriv'd* at the *Meridian*, the Sun has not reach'd it; for while the Earth by its *Motion* round its Axis, has made the *Diurnal Phenomena* of the Revolution of the Equator, the Sun in his apparent Annual *Motion* having moved almost a Degree towards the *East*, therefore a small Portion of *Time* must be allowed more than the *Revolution* of the *Equator*, to compleat an *Astronomical* or *Natural* Day; and by reason of the Inequality of the apparent *Motion* of the *Sun*, together with the Obliquity of the

Ecliptick, which makes the *Arch* of the *Equator* answering to the several Degrees thereof unequal; therefore that additional part of *Time*, which is every Day to be added to the *Revolution* of the *Equator*, to compleat the Time of the Sun's departing from any one *Meridian* till his Return to the same again, must be unequal; and from this arises the Inequality of *Natural Days*.

The *Natural Day* is called *Civil*, because it is by divers Nations reckoned divers ways: The *Babylonians* began to account their Day from Sun *rising*; the *Jews* and *Athenians* from Sun *setting*, whom the *Italians* follow to this Day; the *Egyptians* began at *Midnight*, which is the Custom of the *British*, *French* and *Germans*, with several other *European Nations*: But most *Astronomers* begin their Day at *Noon*.

An Hour is commonly called the 24th Part of a Day, it being that by which the whole Time of *Night* and *Day* is divided into 24 equal Parts: But unequal *Hours* are those by which the Time of the *Artificial Day* is always divided into 12 equal Parts, and the *Nights* into as many. It is called *Temporary*, because of a various length in diffe-

different Times or Seasons of the Year; thus, the Summer Diurnal *Hour* is longer than that of Winter, and the Winter *Nocturnal* Hour longer than that of Summer. At the time of the *Equinoxes* the Nocturnal and Diurnal *Hours* are equal; and to all those that live on the *Equator*, they are always equal, also to those that live *nigh* to the *Equator*, their Inequality is but small.

The equal *Hours* were always used by *Astronomers*, and are now in use among almost all Nations, and are subdivided into 60 equal Parts called *Minutes*, and each *Minute* into 60 equal Parts called *Seconds*. Such as begin to account the *Hours* of the Civil Day from *Morning* or *Evening*, do it because the *Sun* is then in the *Horizon*, the most perceptible of all the *Circles* of the *Sphere*.

A *Month* is that Part of *Time* by which we usually divide a *Year* into 12, or into 13 Parts, and is either *Astronomical* or *Civil*.

Astronomical Months are those that are measured by the *Motion* of the *Luminaries*, and are therefore divided into *Lunar* and *Solar Months*.

Again,

Again, a *Lunar Month* is either *Periodick*, in which the Moon having departed from any Point of the *Zodiack*, returns to the same again, and consists of 27 Days 7 $\frac{3}{4}$ Hours; which is that Space of *Time* wherein the *Moon* runs thro' all its several Phrases, and on that account, is of *principal* use in the marking out of *Time*. The Difference between a *Periodical* and *Synodical* Month is this; the first is called *Periodical*, only in respect to the Moon's *Orbit*, but the *Synodical* is so called, in respect of its *Conjunction* with the Sun: Now after the *Time* of its *Conjunction*, the Sun does not continue in the same Place of the *Ecliptick*, but moves forward towards the *East*, upon which it happens, that the *Moon* finishing its Course, does not find the *Sun* again in the same Point where it left him, he being removed almost a whole *Sign* from his former Place, so that to overtake the *Sun* again, it plainly appears, that a certain Space of *Time* is requisite besides the *Periodical*, which makes up the *Synodical* Month. The *Quantity* of a *Synodical* Month is not the same at all Times, for in *Summer* when the *Sun* seems to move slowest, the *Synodical* Month

Month appeareth less than in *Winter*, when the Sun's Motion appears swifter, the *Moon* not overtaking the Sun so soon.

The *Solar Month* is that Space of *Time* wherein the *Sun* appears to run thro' one of the 12 Signs of the *Zodiack*, by its proper Motion from *West* to *East*, among which there is very great Inequality, because the *Sun* in *Cancer* seems to us to move slower, for which Reason the *Month* of the Summer *Solstice* contains near 31 Days 11 Hours; but in *Capricorn* the Motion of the *Sun* appears more *swift*, the *Solar Month* then consisting only of about 29 Days, 8 Hours; the Mean Quantity therefore of every *Solar Month* will be about 30 Days 10 Hours, that is, when the *Sun* is in the *Equinoctial* Signs.

The *Civil* or *Political* Month is a System of Days, which different *Nations* differently observe in their *Civil* Affairs, according to their voluntary *Institutions*; for some, as the *Egyptians*, liked the *Solar* Months, and made each of them to consist of 30 Days, and to compleat the *Year*, at the end of 12 such *Months*, they annexed 5 Days, made up of those Hours that arise
from

from the 10 Hours, that each *Solar Month* exceeds 30 Days.

But most of the *Antients* fancied the *Synodic Lunar Months* most ; such as the *Jews*, the *Grecians* and *Romans* to *Julius Caesar's* Time, and the *Mahometans* at this Time ; but that those sort of *Lunar Months* that do not consist of whole Days, might be fitted to *Civil Use*, they divided the odd Hours so, as to make their *Civil Months* alternately, to consist of 30 and 29 Days ; so that two such *Months* are equal to two *Lunar Months* of $29 \frac{1}{2}$ Days each, and the new Moon would not remove from the first Day of the *Civil Month* in the Space of some *Years*.



S E C T. II.

Of the Division of Time into Years.

A *Year* is a certain Space of Time, the Parts of which are commonly called *Months*, and is either *Astronomical* or *Civil*.

The *Astronomical Year* is also two-fold; namely, the *Sydereal* and *Tropical*.

The *Sydereal Year* is that Space of *Time* that the *Sun* having departed from a fixed Star returns to the same again, being 365 Days 5 Hours, and 10 Minutes *nearly*. The *Tropical Year* is that wherein the Sun departing from one of the *Cardinal* Points, *viz.* the *Equinox*, or *Solstice*, returns to it again, and is something less than the *Sydereal*, because the *Cardinal* Points of the *Ecliptick* themselves go backwards about 50 Seconds, as it were meeting the Sun, makes the *Sun* return to the same Point of the *Ecliptick* about 21 Minutes sooner than to the same fixed Star where that Point of the *Ecliptick*

was, when the Sun was before in the said Point. Therefore the *Tropical Year* consists of 365 Days, 5 Hours and $49 \frac{1}{2}$ Minutes very near. But whereas the *Hours* and *Minutes* above the whole Days of a *Solar Year*, can't be taken Notice of in *Civil* or common Use; therefore the *Civil* or *Solar Year* in use among us, is made to consist only of 365 Days, for three Years together, and every fourth *Year* of 366 Days, the *Solar Year* having 5 Hours $49 \frac{1}{2}$ Minutes very near above the whole *Days*, there are added every *Year* about 11 Minutes to make 6 Hours, and these 6 Hours amount just to a whole Day in four *Years*.

The *Civil Lunar Year* consists of 12 Lunations or *Synodick Months*, which is finished in 354 Days, at the end of which, the *Year* begins again. It has this Inconvenience, that the same *Months* in several *Years* have not the same Season; the occasion of which is, that the *Lunar Years* being less than the *Solar* by almost 11 Days, in three *Years* time, every *Month* will have the *Season* of that which went before it; hence it is, that the *Beginning* of this *Year* falling upon the *Spring* now, in 8 *Years* time would fall upon *Winter*, and 8 *Years* after that
would

would *begin* in *Autumn*, then in *Summer*, and lastly, at the end of 33 *Years*, return to the *Spring* again, and this is called the *wandering Lunar Year*, because its Beginning wanders thro' all the *Seasons* of the *Year*. This *Year* is in Use among the *Turks*; but the *Jews*, who follow the *Moon's Motion* in their Accounts, retain still the same *Seasons* in the same *Months*, for as often as there is the Difference of 30 Days between the common *Lunar Year* and the *Solar Year*, they intercalate a *Month*, by which Means the *Lunar* and *Solar Years* are kept so adjusted one to the other, as that the *Lunar Year*, will keep in a manner fixed to the same Part of the *Solar Year*.

The *Turks* and *Arabians* make use of the *Lunar Year*, somewhat adapted to *Civil Use*; and the same Custom is also observed in *Tartary*, *Siam* and *Japan*, and other Places.

Political or *Civil Years* are us'd in the Regulation of *Civil* or *Ecclesiastical Affairs*, and in adjusting their Measure, Regard is had to the *Motion* of the *Luminaries*.

There are several Sorts of *Civil Years*, among which, that call'd the *Julian* is the most celebrated.

It derives its Name and *Institution* from *Julius Caesar*. He observing the *Egyptian Year* to get before the *Tropical*, because the 6 Hours it wants of the *Tropical* are intirely neglected in its *Constitution*, did therefore add those 6 Hours to each *Julian Year*, so that a *Julian Year* consists of 365 Days, 6 Hours; and because this Quarter of a Day can't be considered or taken Notice of in *Civil Use*, he ordered the 6 Hours to be neglected till they made a Day, which happening every 4th Year was to be inserted, by way of *Intercalation*, between the 23^d and 24th of *February*; therefore from that Time they write the sixth of the *Calends* of *March* twice, from which the *Year* had the Name of *Bissextile*. And this *Julian Year* of 365, and every 4th Year 366 Days, is the best fitted for *Astronomical Computations*, because it is a Mean between the *Natural* or *Tropical Year* of 365 Days, 5 Hours and 49 Minutes, and the *Sydereal Year* of 365 Days and 10 Minutes; and does as it were, give an Ocular *Demonstration* of the Equinoxes. But this *Julian Year*, the Quantity of it must be own'd to be too big, on which Account the beginning of this
Year

Year also, by little and little, creeps forwards in regard of the *Seasons*, or (which is all one) the Times of the *Equinoxes* and *Solstices* go backward in regard of the Days of this *Year*. And since this Regress is about $10 \frac{4}{5}$ Minutes every Year, in about 133 Years it will be the Matter of a Day, and consequently from the *Year* of *Christ* 325, wherein the *Council* of *Nice* was held, to the *Year* 1582, wherein Pope *Gregory* reform'd the *Calendar*, this Regress amounted to 10 Days. Hence it came to pass, that whereas in the Time of the *Nicene Council*, the *Vernal Equinox* happened near about the 21st of *March*, in the Year 1582, it was found to be about the 11th of *March*; that he might therefore bring the *Equinox* to its former Place, 10 Days were suppress'd in the Month of *October* in the Year 1582, and the 5th Day was call'd the 15th; by this Means, what would otherwise have been the 11th of the *March* following, becomes the 21st of *March*; That is, the *Equinox* happens the same Day as it did in the Time of the *Council* of *Nice*. And that the like *Variation* might not happen again, the said *Pope* ordered, that once in 133 Years, a Day should be taken out of
the

the *Calendar*, or (which comes to the same) that 3 Days should be taken out every *four hundred Years*; and this he appointed to be done, by making every *hundredth Year* of the *Christian Era* common, which according to the *Julian Account* is always *Bissextile*, but every *four hundredth Year* to continue *Bissextile* as in the *Julian Account*. This Form of the Year settled by Pope Gregory XIII. was call'd from him the *Gregorian*, and is observed in *Italy, France, Spain, Germany*, and wheresoever the *Authority* of the *Pope* reaches.

As the Form of the *Year* among different *Nations* is *various*, so likewise is its Beginning: The *Jews* begin their *Ecclesiastical Year* with the *new Moon* of that *Month*, whose full *Moon* happens next after the *Vernal Equinox*: The *Church of Rome* begin their *Year* with the *Sunday* that happens next after the said full *Moon*, or with the *Feast of the Resurrection* of our *Lord*.

The *Jews* begin their *Civil Year* with the *new Moon* that has its full *Moon* happening next after the *Autumnal Equinox*.

The *Grecians* begin their *Year* with the *new Moon* that happens next after the *Summer*

mer *Solstice*. The *Romans* anciently began theirs with the *new Moon* that happens next after the *Winter Solstice*, and this seems to be the Reason why *Julius Cæsar* fix'd the Beginning of his *Tear* to the *Calends* of *January*.

The more *celebrated* Collections of *Years*, or *Times* measured by a *Repetition* of *Years* are an *Olympiad* of 4 *Years*, a *Jubile* of 49 or 50 *Years*, and an *Annus magnus*, or *great Year*, standing for an intire Revolution of the fixed *Stars*; till after having departed from a *fixed Point*, they return to the same again, which is 25000 or 26000 *Years*. And thus much for the several Parts into which Time in *general* is distinguished.



S E C T. III.

Of the Cycle of the Moon.

THE *Lunar Cycle* is a *System* of 19 Years, in which Time the *new Moons* return to the same Days they were on before, and she begins again her Course with the *Sun*.

This was begun by *Melon the Athenian*, and is called the *Golden Number* ; for supposing the Sun and Moon to be in Conjunction the 1st Day of the *Year*, at the end thereof, the *Moon's 12 Months* will be finished 11 Days sooner than that of the *Sun*, so she will be at the end of the *Sun's Year*, 11 Days before him, and in 2 *Years* 22 Days before him, &c.

All these *Variations* are finished in 19 *Years*, nearly agreeing with the Course of the Nodes of the *Moon* ; that is, the Points where her *Orbit* crosses the *Ecliptick*.

If the *Lunations* be observed and set down for a whole *Course* of the *Golden Number* or Cycle of 19 *Years* ; which is the Cycle
of

of the *Moon*, the same Observations will serve through the next Cycle of 19 *Years*, and will continue so for some Time, and therefore the *Golden Number* in the first *Column* of the *Calendar* before the Book of *Common-Prayer*, shews the Days of the Month the *new* and *full* Moons happen on.

The *Antients* did imagine that the Cycle of 19 *Years* did exactly compleat 235 *Lunations*, and therefore after the *Revolution* of that *Time*, the new Moons not only fall on the same Days of the Month, but likewise on the same Hours of the Day, which is not true; for in 19 *Julian Years*, there are 6939 Days and 18 Hours: But allowing to every *Lunation* 29 Days, 12 Hours, 44 Minutes, 3 Seconds, which the *Motion* of the *Moon* requires, 235 such *Lunations* will make 6939 Days, 16 Hours, 31 Minutes, 45 Seconds: Therefore 235 *Lunations* are not equal to 19 *Julian Years*, but are less by one Hour and an half, and consequently the new Moons after 19 Years will not return to the same Hour, but will be an Hour and an half sooner, and in 304 *Years* they will anticipate a whole Day. And there-

fore the *Golden Number* will, precisely enough for common Use, shew the *Lunations* for the Space of three *Centuries*, without the Error of one Day.

In the *Council of Nice*, when the *Cycle* of the Moon was fitted to the *Calendar*, and some Centuries afterwards, it did nearly enough, give the Time of the *new Moons*: But the *Lunations* in every 3 or 4 *Years* anticipating a whole Day, they now happen almost five Days sooner than they should do according to the Rule of the *Golden Number*. Notwithstanding this, the *Church of England* retains the way of computing by the *Golden Number* as it was disposed in the *Calendar* at the Time of the *Nicene Council*, and the *new Moons* computed after that manner are called *Ecclesiastical new Moons*, to distinguish them from the true ones in the *Heavens*; and the general *Table*, or *Rule* for finding *Easter* for ever, which is in our *Liturgy*, by the *Golden Number* and *Dominical Letter*, is made according to that Disposition of the *Golden Number*.

In the first Year of the *Christian Æra*, Two was the *Golden Number*, and therefore if
to

(19)

to the Current *Year* of *Christ* we add One, and divide that *Sum* by 19, the *Remainder* is the *Golden Number*, and if nothing remain, 19 is the *Golden Number* for that *Year*.



S E C T. IV.

Of the Epacts.

U N D E R the Name of *Epacts* we usually understand the Difference between a *Lunar* and a *Julian Year*; for the common *Lunar Year* not being equal to, but less than the *Julian*, and both being made use of in the *Ecclesiastical Computation*, some *Authors* bethought themselves of reducing the one to the other.

It has been observed in the preceeding Section, that the *Civil Lunar Year* is 11 Days shorter than the *Solar*: Consequently two such *Lunar Years* will be 22 Days, and three *Lunar Years* will be 33 days shorter

§ 2

than

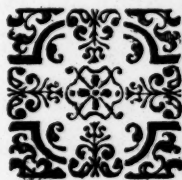
than three *Solar Years*. Now those that use the *Lunar Year* in order to adjust it to the *Solar*, as often as the *Lunar Year* comes to be 33 Days shorter than the *Solar* do intercalate a Month of 30 Days into the *Lunar Year*, and by this Means the *Civil Lunar* and *Solar Years*, are kept so adjusted to one another, as that the first Year of the Moon's Cycle comes not shorter of the *Solar Year* than 11 Days, the second *Year* not shorter than 22 Days, and the third Year than 33 Days.

And as the *new Moons* fall on the same Day every 19th Year, so the Difference between the *Solar* and *Lunar Year* is the same every 19th Year; and because the said Difference is always to be added to the *Lunar Year*, in order to adjust or make it equal to the *Solar Year*, hence, the said Difference respectively belonging to each *Year* of the *Moon's Cycle* is call'd the *Epaēt* of the said Year, that is, the Number to be added to the said *Lunar Year*, to make it equal to the *Solar Year*.

To find the *Epaēt* for any *Year*, multiply the *Golden Number* (that is, the Cycle of the Moon) for that Year by 11, the Product,
if

if less than 30, is the *Epaēt* sought ; if the Product be greater than 30, divide it by 30, and the Remainder is the *Epaēt* for the *Julian Account*. The *Epaēt* for the *Julian Account* being known, the *Epaēt* for the *Gregorian Account* may easily be found ; thus, if the *Julian Epaēt* be greater than 11, *subtracting* 11 from it leaves the *Gregorian*, but if the *Julian Epaēt* be less than 11, add 30 to it, and from that Sum *subtract* 11, the Remainder will be the *Gregorian Epaēt*.

The Day of the *Month* the *new Moon* falls on may be known by the Help of the *Epaēt*, thus ; To the Number of the *Months* from *March inclusively*, add the *Epaēt* of the *given Year*, if the Sum be less than 30, subtract it out of 30 ; but if *greater*, subtract it out of 60, and the Remainder will be the Day on which the *new Moon* falls.



S E C T. V.

Of the Cycle of the Sunday-Letter, commonly called the Cycle of the Sun.

THE *Weekly Character* is that *whereby* we distinguish one Day of the *Week* from another : The *Week* is a System of 7 Days continually returning, and to this End *Divinely ordained*, that the *Memory* of the Six Days *Creation* might be preserved. We describe the Days of the *Week* by Seven different *Names* ; as, *Sunday, Monday, Tuesday, &c.* and to distinguish them in the *Calendar*, there are *Seven* Letters appropriated, and set in *Alphabetical* Order before them, and so repeated throughout the whole *Year*, viz. A, B, C, D, E, F, G, and some one of these is the *Dominical Letter*, or the *Letter* for *Sunday*, and the *Letters* following, for the other Days of the *Week*.

The

The *Sunday-Letter* is not always the same, but is *changed* once every common Year, and twice in every fourth or *Leap-Year*. The Reason is, first, because the common Year does not consist of entire *Weeks*, but of 52 *Weeks* and one Day; so that the *Year* beginning with A, prefixt to *New Year's Day*, it will likewise end with A, prefixt to the last Day; and the *Year* beginning again with A, there will be two A's falling together, viz. *December 31*, and *January 1*, and if one of them (*i. e.* the former) happen to be *Sunday*, the other in Course must stand for *Monday*, and then *Sunday* must fall upon the *preceding G*, which will be the *Dominical Letter* for the ensuing *Year*; thus, the *odd Day* shifts back the *Dominical Letter* every Year by one *Letter*, and this *Revolution* would be performed in *Seven Years*; but there comes in another *odd Day* every fourth *Year*, being *Leap-Year*, in which the *Sunday-Letter* is changed twice; once at the beginning of the Year, and once towards the latter end of *February*, by Interposition of the Intercalar Day called *Bissextile*, because the sixth of the *Calends* of *March* is twice repeated.

To take a more easy Account of these *Changes*, there is *appropriated* a Cycle which comprehends in order, all the *Variations* of the *Sunday-Letter*, and is therefore called the Cycle of the *Sun*, composed of four, the *Changes* which make the *Leap Year*; and of Seven, the *Changes* of one Day throughout the *Week*, which 4 times 7, or 28 *Years*, compleat all the *Varieties* of the *Dominical Letters*.

The *Dominical Letters* shifting in a *Retrograde Order*, it follows, that if this Year have G for its *Dominical Letter*, F will answer to the next, and in *Leap Years*, which have double *Dominical Letters*, the one serving for *January* and *February*, and the other for all the rest of the Year, the same *Retrograde Order* is observed.

To find the *Dominical Letter* for any Year of our *Lord*. The Year proposed divide by 4, (neglecting the Remainder) add 4 to the *Quotient*, which Sum add to the same Year proposed, and that Sum divide by 7; if nothing remain, G is the *Dominical Letter* for that Year; but if there be any Remainder, *Subtract* it from 7, and that last Remainder will shew the Number of
the

the *Dominical Letter* from the beginning of the *Alphabet* for that Year. The *Sunday-Letter* being known, its easy by the Help of the following Verses, to tell what Day of the *Week* the first Day of any *Month* falls upon; the Order of the Words answering to the Order of the *Month* runs thus,

<i>Jan.</i>	<i>February,</i>	<i>March,</i>	<i>April, May,</i>	<i>June,</i>
<i>At</i>	<i>Dover</i>	<i>dwells</i>	<i>George Brown, Esquire.</i>	
<i>July,</i>	<i>August,</i>	<i>Sept.</i>	<i>Octob. Nov.</i>	<i>Dec.</i>
<i>Good</i>	<i>Christopher</i>	<i>Finch</i>	<i>and David</i>	<i>Fryer.</i>

I would *know* what Day of the *Week* *July* the First 1725 falls upon. The *Sunday-Letter* for that Year being C, by the foregoing Verses I know G is the Letter belonging to *July* 1st. which in *Alphabetical* Order is the fourth Letter from the *Dominical Letter* C, and therefore *July* begins on *Thursday* the fourth Day after *Sunday*, because G in the Order of the *Alphabet* is after the *Dominical Letter* C.

S E C T. VI.

Of the Roman Indiction and Julian Period.

THE *Cycle of Indiction* is a System of 15 *Julian Years* perpetually returning, by which the Times of certain *Payments* were made known to the *Roman Subjects*. When this Cycle was first instituted is uncertain, but its evident from *History*, that it has been in use ever since *Constantine the great*, or from the Year of our *Lord* 312.

There are commonly reckon'd three Sorts of *Indictions*, whereof the first was called the *Cæsarian*, because the *Cæsars* had Respect to it in the *Payment of Taxes*; this Indiction fell on the 8th of the *Calends of October*.

The second was called *Constantinopolitan*, by which they marked the more *Oriental Calendars*. This began on the *Calends of September*, whence some think that its Use began when the *Grecians* chose the *Autumn*,
and

and the first Month of it for the Solemnity of the new Year.

The third is called the *Pontifical* which begins upon the *Calends* of *January*, and continually follows the two former, at the *Distance* of almost four *Months*. This *Indiction* is still used by the *Pope* in his *Bulls*, &c. The Year of the *Roman Indiction*, answering to any given Year of *Christ*, is found by adding 3 to the given Year of *Christ*, and dividing the Sum by 15, the Remainder shews the *Indiction*, but if nothing remains, it is the 15th or last Year of the *Indiction*.

The *Julian Period*, is a System of 7980 Years, and arises from the continual *Multiplication* of 19 the *Cycle* of the *Moon*, 28 the *Cycle* of the *Sun*, and 15 the *Roman Indiction*. The first Year of this Period had One for the *Character* of the *Solar Cycle* as well as of the *Lunar Cycle*, and of the *Indiction*. It is called the *Julian Period*, because it was adapted by the Author or Inventor of it, *Joseph Scaliger*, to the *Julian Years*, in respect of its Use. This *Period* is the Standard or common Receptacle of all other *Epochas*; so that we are chiefly to reduce all other *Eras* to it, and by that

we can *explain* to one another; for every Year in this *Period* has its *peculiar Cycles*, no two *Years* in the *whole Period* having the same Numbers for all the *Cycles*; whereas, if we reckon by the Year of the *World*, we must first enquire how many *Years* any *Author* reckons from the *Creation* to the Year named, which is troublesome and full of Difficulties, according to the Method of other Periods.

To know what Year of the *Cycle* of the *Sun*, *Moon*, or *Indiction* answers to any given Year of the *Julian Period*; Divide the given Year respectively by 28, or 19, or 15; the Remainder of the first Division will shew the Year of the *Sun's Cycle*; the second Remainder the Year of the *Moon's Cycle*, and the third Remainder the Year of the *Indiction*, and if nothing remains in each Division, then it is the last Year of each *Cycle* respectively.

On the contrary, to know what Year of the *Julian Period* answers to any given Year of the *Cycle* of the *Sun*, *Moon*, or *Indiction*; Multiply the *Cycle* of the *Sun* into of 4845, the *Moon* into 4200, the *Cycle* of the *Indiction* into 6916. The Sum of the *Products*

ducts being divided by 7980, the *Remainder* will shew the Year of the *Julian Period* sought.

To find what Year of the *Julian Period* any given Year of *Christ* answers to ; To the given Year of *Christ* add 4713, and the Sum gives the Year of the *Julian Period* sought. On the contrary, having the Year of the *Julian Period* given, to find what Year of *Christ* answers thereto ; From the Year of the *Julian Period* given, subtract 4713, and the Residue will be the Year of *Christ* sought.



S E C T. VII.

Of Epochas and Æras.

AS the *Astronomers* in computing the *Motions of Celestial Bodies*, assume certain *fixed Points*, so they do certain *Moments of Time*, from which, as *Roots*, their *Computations* may begin and proceed. These *Roots* are called *Epochas* or *Æras*, and commonly have a Name from some famous *Action* or Event that happened near the Beginning of each. The most *considerable*, and that with which we are best *acquainted*, is the *Epocha* of *Christ's Nativity*, or the first Day of the *January* that we suppose to follow next to the *Nativity* of our *Lord*. The *Æra* or Way of reckoning from *Christ*, was first introduced by one *Dionysius*, about 500 Years after *Christ*, since which Time *Christians* have reckoned their *Years* either from the *Birth* or *Incarnation* of our *Blessed Saviour*. According to *Dionysius*, the Author of the *Æra* computed

puted from *Christ* our Saviour, was conceived on the Eighth of the *Calends* of *April* (now called *Lady-day*) in the first of this *Æra*, and was born about the then *Winter Solstice* next following, that is, *December* the 25th, and this Account was at first universally received among *Christians*, but is now only us'd in *Great Britain* and *Ireland*; where not only the *Ecclesiastick*, but also the *Civil Year* is still reckoned according to Law from the Feast of the *Annunciation*, or *Lady-day*, as it was at first by *Dionysius* himself, whereas, in the other Parts of *Christendom*, (and even in *England*, as to common Affairs) the Year of *Christ* is now reckoned from the first of *January* next before the *Lady-day*, from which the *Legal* Date of our *Ecclesiastical* or *Civil Year* begins.

There is also another *Æra* frequently made use of by *Christian Writers*, namely the *Æra* of the *World's Creation*, which is generally believed to be about 3949 *Years* from the beginning of the *World* to the *Birth* of *Christ*. *Kepler* makes it 3993 before *Christ*. *Hevelius* says the *World* was created in the 3963 Year Current before *Christ*, the 24th of *October* of the *Julian Year* continued backwards. The

The most antient and renowned *Epocha* used by the *Heathens*, was that of the *Olympiads* or *Olympick Games*, used among the *Greeks*, which were instituted by one *Pifus*; but *Pelops* the Son of *Tantalus* is much more famous in *History*, who ordered them to be celebrated in Honour of *Jupiter Olympius*, in the *Elean Fields* in the *Peloponesus*, which is now called *Morea*; the Games lasted five Days, the last whereof fell on the full *Moon*, which was next after the *Summer Solstice*.

They were Celebrated every fourth Year. The Year wherein the *Olympiad* was celebrated being called the first Year of the said *Olympiad*, and so on.

The Celebration of the first *Olympiad* is referred to the 3938 Year of the *Julian Period*, and consequently to the 777 Year before *Christ*. Any Year of the *Olympiads* being given, to find the corresponding Year before or after *Christ*, work thus, Multiply the compleat *Olympiads* by 4, and to the Product add the Year (if any be specified) of the *Olympiad* running; this Sum, if it be less than 776, subtract it from 776, and the Remainder will shew the corresponding Year

Year before *Christ*; but if the Sum be greater than 776, then subtract 776 from it, and the Remainder will shew the corresponding Year after *Christ*.

Any Year of the *Olympiads* being given, the corresponding Year of the *Julian Period* may be found thus, Multiply the compleat *Olympiads* by 4, and to the Product add the Year (if any be given) of the *Olympiad* running, and to that Sum, add 3937, the Year of the *Julian Period*, which was the first of the *Olympiads*; that Sum is the Year of the *Julian Period* sought.

Also any Year of the *Julian Period* being given to find what *Olympick* Year answers thereto; work thus, from the Year given subtract 3937, and divide the Remainder by 4, the *Quotient* will shew the compleat *Olympiads*, and the Remainder will shew the Year of the *Olympiad* running, if there be no Remainder, then it is the last or fourth Year of the *Olympiad* running.

As the *Account* by the *Olympiads* was the chief *Era* among the *Greeks*, so the principal *Era* among the *Romans* was that of the building of *Rome*, which according to *Varro's Account*, began with the *Julian*
c
Period

Period 3961 ; but according to *Cato*, the City of *Rome* was begun to be built in the Year of the *Julian Period* 3962. If therefore according to *Cato*, 3961 Years and 3 Months, or according to *Varro*, 3960 Years and 3 Months, be subtracted from any certain Year of the *Julian Period*, the Residue shews the Year since the Beginning of the *Epocha* of the *Building* of *Rome*, but if the above-mentioned Numbers be added to the Time of the said *Epocha*, the Product will correspond with the Year of the *Julian Period*.

Rome is computed to have been built 752 Years before *Christ*, therefore from 752, subtract any given Year of the *Roman Era* or Building of *Rome*, and the Remainder will shew the correspondent Year before *Christ*, or if the Year given of the *Building* of the City be greater than 752, then subtract 752 from it, and the Remainder will shew the correspondent Year after *Christ*.

Other *Epocha's* or *Era's* being of less Note and Use to us, it will be sufficient to shew in short how long before, or after *Christ* each of them began.

The

Before Christ

The *Destruction of Troy* happened in the 3530 Year of the *Julian Period*, Cycle of the Sun 2, Moon 15. } 1184

The *Æra of Nabonassar King of Babylon*, from the Beginning of whose Reign, the *Chaldeans* and *Egyptians* reckon'd their Years began February 26, *Julian Period* 3967, Cycle of the Sun 19, Moon 15. } 747

The *Æra of the Death of Alexander the Great* began November 12, *Julian Period* 4390, Cycle of the Sun 22, Moon 1. } 324

The *Æra of the Julian Reformation of the Calendar* began January 1, *Julian Period*, 4669 } 49

After Christ

The *Dioclesian Æra*, or *Æra of the Martyrs*, otherwise called the *Æra of the Abissinians*, began August 29, *A. D.* } 284

The *Æra of the Hegira* or Flight of *Mahomet*, from *Mecca* to *Medina*, used by the *Turks* and *Arabs*, began July 16, *A. D.* } 622

The *Æra of Tezdegird* or the *Persian Æra*, began July 16 } 632
A. D.

From

From the *Table* of the Beginning of the fore-mentioned *Æras*, it's easy to find out the *Year* before or after *Christ* which answers to any *Year* given of the said *Æras*, which are computed by *Julian Years*.



Of the Epochas of the principal Kingdoms of Europe.

I. *GERMANY* was first made a separate *Kingdom*, *A. D.* 840, *Julian Period*, 5553.

The *Title* of *Emperor* of the *Romans* was first assumed by the King of *Germany*, 878, *Julian Period*, 5601.

The *Austrian Family* which now enjoys the *Imperial Dignity*, is descended of *Rodolph*, *Earl* of *Hadsburgh* and *Landgrave* of *Alsace*, who was chosen *Emperor* *A. D.* 1273, *Julian Period*, 5986.

II. The *Gothick Race* came first to the *Crown* of *Spain*, *A. D.* 410, *Julian Period*, 5123.

The

The *Moors* dispossess'd the *Goths*, *A. D.* 713, *Julian Period*, 5426.

The *Moors* were totally extirpated out of *Spain*, *A. D.* 1492. *Julian Period*, 6205.

III. *Portugal* was made a separated Kingdom from *Spain*, *A. D.* 1139. *Julian Period*, 5852. It was united again to *Spain*, *A. D.* 1580. *Julian Period*, 6293.

Portugal shook off the *Spanish Yoke*, and became once more a separate Kingdom, *A. D.* 1640. *Julian Period*, 6353.

IV. *France* was first possess'd by the *Franks* and modelled into the Form of a Kingdom, *A. D.* 424, *Julian Period*, 5137. The first of the present Race of the Kings of *France* mounted the Throne, *A. D.* 987, *Julian Period*, 5700.

V. In adjusting the *Epocha* of *England*, we ought to mind the following Characters.

1. The *Saxons* invaded *England*, *A. D.* 450. *Julian Period*, 5163.

2. King *Egbert* sunk the Distinction of *Saxons* and *Britons*, and called the whole Country *England*, *A. D.* 818. *Julian Period*, 5531.

3. The *Danes* possessed the Crown of *England* from 1017 to 1042 of the *Vulgar Epocha* of *Christ*, *Julian Period*, 5755.

4. The

4. The Normans invaded England, *A.D.* 1066, *Julian Period*, 5779.

5. The Houses of Lancaster and York united *A.D.* 1399. *Julian Period*, 6112.

6. The Scots Kings succeeded to the Crown of England, *A.D.* 1602. *Julian Period* 6315.

VI. The *Epocha* of the Kings of Scotland commenced with *Fergus* the First, 330 Years before the Birth of Christ, in the 4336th Year of the *Julian Period*, in the Time of *Alexander* the Great.

2 *Fergus* the Second, the 40th King of Scotland restor'd the Scots, after they were almost extirpated by the Britons and Picts in the Year of Christ, 403.

Kenethus the Second, the 69th King of Scotland, conquered and extirpated the Picts in the Year of Christ, 834.

3. King *James* the Sixth of Scotland, succeeded to the Crown of England, and united both Kingdoms into one *A.D.* 1602.

VII. Sweden was conquered by *Othin* 24 Years before Christ; in the 4690 of the *Julian Period*.

2. *Gustavus*

2. *Gustavus Erickson* shook off the *Danish Yoke*, and had the *Crown of Sweden* settled on his *Posterity*, *A. D.* 1544. *Julian Period*, 6267

VIII. The *Oldenburgh Family* was preferred to the *Crown of Denmark*, *A. D.* 1449. *Julian Period*, 6162.

IX. *John Czar of Muscovy* made *Muscovy* an independant *Empire*, *A. D.* 1470. *Julian Period*, 6183.

X. The *Commonwealth* of the *Seven United Provinces* of the *Netherlands* takes Date from the *Union* concluded at *Utrecht*, *A. D.* 1579. *Julian Period*, 6292.

XI. The *Confederate Republic* of *Switzerland* takes Date from the *Year of Christ*, 1320. *Julian Period*, 6033.

XII. The *Power of the Waywood's* in *Poland*, was exchanged for that of a *King*, *A. D.* 700. *Julian Period*, 5413.

2. These *Kings* were declared independant of the *Empire*, *A. D.* 999. *Julian Period*, 5712.

XIII. The *Epocha* of the *Papal Hierarchy* commences from the time of *Boniface III. Bishop of Rome*, who assumed the *Title*

tle of Oecumenical Bishop, A. D. 606, Julian Period, 5219.

XIV. The *Epocha* of the *Reformation* takes its Date from the 1517 Year of the *Vulgar Epocha* of *Christ*; and of the *Julian Period*, 6230, that being the *Year* in which *Luther* (the first *Reformer*) wrote against *Indulgencies*.

F I N I S.

